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A Bibliometric Analysis of Computational Mapping on Publishing Teaching Science Engineering using VOSviewer Application and Correlation

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ABSTRACT

The purpose of this study was to describe the development of research in the field of teaching science engineering using VOSviewer. This research was conducted by creating a journal database from the Publish or Perish application and managed with the VOSviewer application to classify and visualize the database using the keyword of "Teaching Science Engineering" in the last 10 years (form 2012-2021). A total of 998 articles related to teaching science engineering were analysed and mapped. Based on the mapping results, three terms were obtained, namely "Mathematics" which was associated with 51 links and 335 link strengths; "Engineering Education" associated with 49 links and 146 link strengths; and "Science Technology Engineering Mathematics (STEM)" associated with 48 links and 270 link strengths, respectively. In addition, an analysis of the findings showed that teaching science engineering research in 2012-2016 experienced fluctuating developments. Meanwhile, from 2017 to 2021, teaching science engineering research continues to experience a significant decline. The significant decline in 2019-2021 occurred due to pandemic conditions that impacted the teaching of science engineering related to direct practice in the field. Therefore, it is hoped that the study can help and become a reference for researchers in conducting and determining the research themes to be taken.

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1. INTRODUCTION

Teaching science is something that must be done by students. It is not something that is done to students (Novak & Wisdom, 2018). Teaching science requires students to learn actively which is implied in physical or mental activities, not only including hands-on activities but also minds-on (Barak, 2020; Arik & Topçu, 2020). Science skills are very important because they are used to study natural phenomena in a certain way to gain knowledge and the development of science and technology is increasingly rapid (Rusyani *et al*., 2021).

Engineering is a growing field of study that is becoming increasingly important for the development of technology and industry (Nandiyanto *et al*., 2021). Engineering has played an important role in the industrial era, especially in efforts to develop and engineer efficient industries (Al Husaeni & Nandiyanto, 2022a). The development of the engineering field that continues to grow can help workers become more effective and efficient (Nandiyanto *et al*., 2021; Al Husaeni & Nandiyanto, 2022a). Therefore, students need to develop science and technology skills because of their enormous benefits in future life. By providing engineering and science teaching, students are not only good at theory but also skilled in applying the theory they get to solve the problems they face (Arik & Topçu, 2020; Jain *et al*., 2018; Klofsten *et al*., 2021).

There have been many types of research in the field of teaching science engineering that has been published such as research conducted by Ozaktas (2013) regarding teaching to complement engineering programs in the field of science, research conducted by Karisan *et al*. (2019) which examined the effects of teaching engineering in the field of science, and research conducted by Kaya *et al*. (2017) which investigated the integrated science teaching in engineering design. Although a lot of research has been done on teaching science, there is no research on bibliometric analysis in the field of teaching science teaching research, especially using VOSviewer software as a tool for mapping. This analysis is important because it can determine the number of research developments. Therefore, the purpose of this study is to analyze teaching science engineering research which was mapped using VOSviewer software. This research is expected to help and be a source for researchers in determining research topics, especially in the field of teaching science engineering.

2. METHOD

In this study, the article data used was data from international research publications indexed by Google Scholar. Publication data from the Google Scholar database was filtered and collected using the Publish or Perish application (as the application reference manager). The keyword "Teaching Science Engineering" is used to search for relevant articles published from 2012 to 2021, which are then saved in CSV and *ris formats. Data in CSV format were analyzed using Excel in the form of the number of publications per year, origin, and subject. Meanwhile, data in *ris format is processed using the VOSviewer application to visualize and analyze trend relationships in the form of networking, density, and bibliometric visualization overlays. In addition, we also filter the terms that will be included in the VOSviewer network mapping visualization and also analyses the difference in the number of publications each year, and classifies the 20 articles with the highest number of citations in each publisher from 988 articles. More detailed information regarding software installation and a step-by-step process for obtaining data as described in our previous studies (Nandiyanto *et al*., 2021; Al Husaeni & Nandiyanto, 2022a; Al Husaeni & Nandiyanto, 2022b).

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3. RESULTS AND DISCUSSION

3.1. Publication Data Research Development in the Field of Teaching Science Engineering

Table 1 is the result of filtering data on articles that have been published for 10 years (from 2012 to 2021) using the publish or perish reference manager, which obtained 998 articles that match the keyword criteria. The data obtained is in the form of metadata with the following information: author's name, title, year, journal name, publisher, number of citations, article links, and related URLs. **Figure 1** shows the development of research on teaching science engineering for 10 years in the period 2012-2021. Based on **Figure 1**, it is known that in 2012-2017 the number of articles researching the teaching of engineering and science experienced fluctuating changes with the number of articles sequentially 123, 126, 144, 134, 144, 127 publications per year. While the number of articles in 2018-2021 experienced a very drastic decrease with the number of articles 90, 66, 37, and 9 publications per year. The main reason for the significant decline that occurred in 2019-2021 was due to the COVID-19 pandemic because it had an impact on science engineering teaching activities which required practice in the field.

Table 1. Development of teaching science engineering research.

Year of Publication	Number of Publications
2012	123
2013	126
2014	144
2015	134
2016	142
2017	127
2018	90
2019	66
2020	37
2021	9
Total	**988**

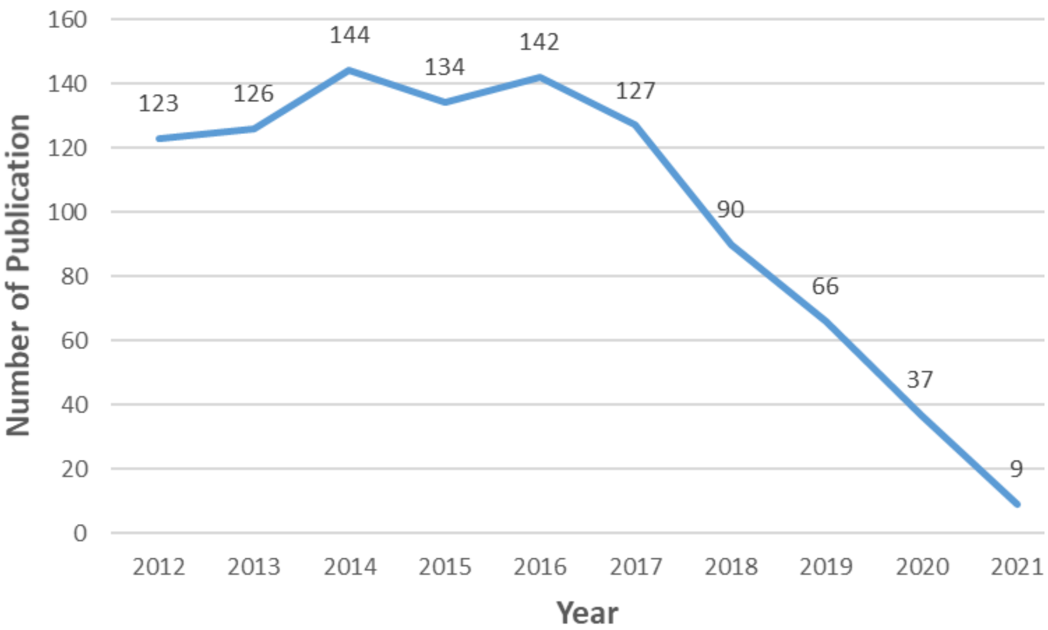

Figure 1. Development of international publications teaching science engineering research topics.

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Table 2 depicts the classification of related articles with the highest number of citations. Based on the article data in **Table 2** obtained from 2012 to 2021, 20 articles with the highest number of citations were obtained. The number of citations from all articles used in this study was 17,445, the number of citations per year was 2,365.43, the number of citations per article was 2.8, and the average of the authors in the articles used was 3.0.

Table 2. Teaching science engineering topics data.

No	Number Citation	Title	Publisher	Year	Authors
1	2698	Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars	ojs.aishe.org	2017	Maguire, and Delahunt (2017)
2	1780	Case studies and the flipped classroom.	JSTOR	2013	Herreid and Schiller (2013)
3	1206	A conceptual framework for integrated STEM education	Springer	2016	Kelly and Schiller (2013)
4	1026	Defining computational thinking for mathematics and science classrooms.	Springer	2016	Weintrop *et al.*, (2016)
5	937	Considerations for teaching integrated STEM education	docs.lib.purdue.edu	2012	Stohlmann *et al.*, (2012)
6	885	Teaching and learning with technology: Effectiveness of ICT integration in schools	International journal of research in education and science	2015	Ghavifekr, and Rosdy (2015)
7	838	Additive manufacturing: current state, future potential, gaps and needs, and recommendations	asmedigitalcollection.asme.org	2015	Huang *et al.*, (2015)
8	806	A review of technological pedagogical content knowledge	JSTOR	2013	Chai *et al.* (2013)
9	770	Cooperative learning: Improving university instruction by basing practice on validated theory	karlsmithmn.org	2014	Johnson *et al.* (2014)
10	664	Challenges to learning and schooling in the digital networked world of the 21st century	Wiley Online Library	2013	Voogt *et al.* (2013)
11	629	Student learning and perceptions in a flipped linear algebra course	Taylor & Francis	2014	Love *et al.* (2014)
12	624	Attitudes towards science, technology, engineering and mathematics (STEM) in a project-based learning (PjBL) environment	Springer	2013	Tseng *et al.* (2013)
13	611	Science aspirations, capital, and family habitus: How families shape children's engagement and identification with science	journals.sagepub.com	2012	Archer *et al.*, (2012)

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Table 2 (Continue). Teaching science engineering topics data.

No	Number Citation	Title	Publisher	Year	Authors
14	610	Computer simulations to support science instruction and learning: A critical review of the literature	Taylor & Francis	2012	Smetana and Bell (2012)
15	581	An elitist teaching-learning-based optimization algorithm for solving complex constrained optimization problems	growingscience.com	2012	Rao and Patel (2012)
16	580	The informed design teaching & learning matrix	teep.tufts.edu	2012	Crismond and Adams (2012)
17	572	Teaching scientific practices: Meeting the challenge of change	Taylor & Francis	2014	Osborne (2014)
18	569	How science, technology, engineering, and mathematics (STEM) project-based learning (PBL) affects high, middle, and low achievers differently: The impact of student factors on achievement	Springer	2015	Han *et al.* (2015)
19	530	Making a difference in science education: the impact of undergraduate research programs	journals.sagepub.com	2013	Eagan *et al.*, (2013)
20	529	A meta-analysis of the efficacy of teaching mathematics with concrete manipulatives.	psycnet.apa.org	2016	Carbonneau *et al.* (2013)

3.2. Visualization Teaching Science Engineering Topics using VOSviewer

Figure 2 shows the network of visualized terms based on the research topic of teaching science engineering. In the network visualization, relationships are represented by networks or lines connecting one term to another. Based on the results of the analysis of the mapping of terms into 4 main clusters with a total of 58 items. Each cluster is marked with a different color.

Cluster 1 marked in red consists of 21 items, namely articles, cases, covid, effectiveness, engineering education, engineering faculty, higher education, implementation, instruction, literature, need, PBL, quality, review, robotic, social science, sustainability, systematic review, teaching method, tool, and use. Based on **Figure 3**, "engineering education" is the main node in the cluster.

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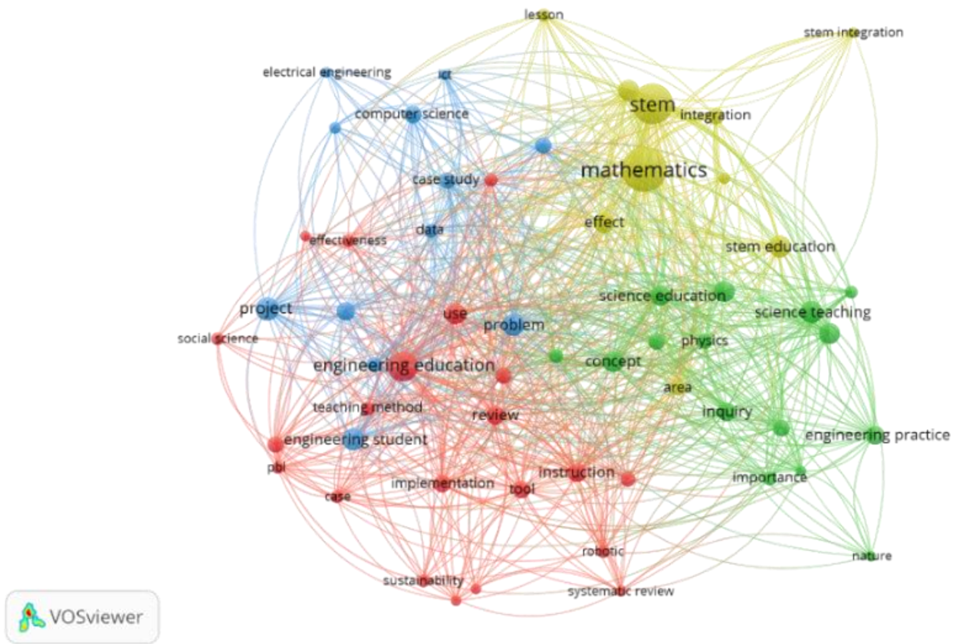

Figure 2. Network visualization based on co-word of teaching science engineering research topics.

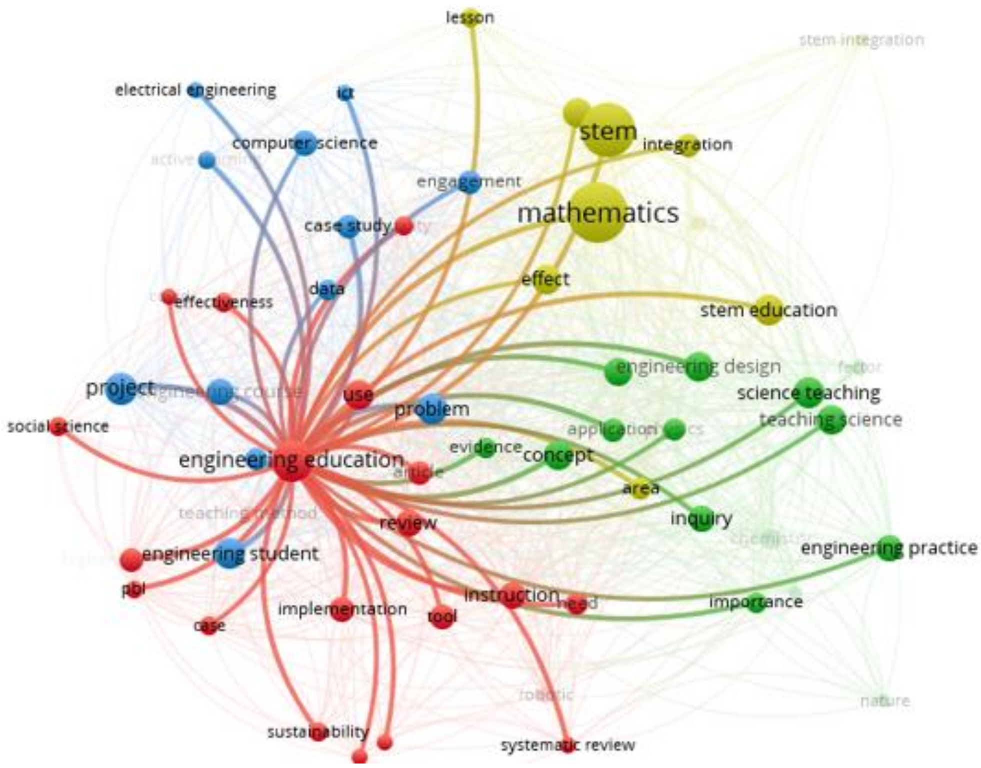

Figure 3. Network visualization of cluster 1.

Cluster 2 is marked in green, consisting of 15 items, namely application, biology, chemistry, concept, engineering design, engineering practice, evidence, factor, importance, inquiry, nature, physics, science education, science teaching, and teaching science. Based on **Figure 4**, "science teaching" is the main node in the cluster.

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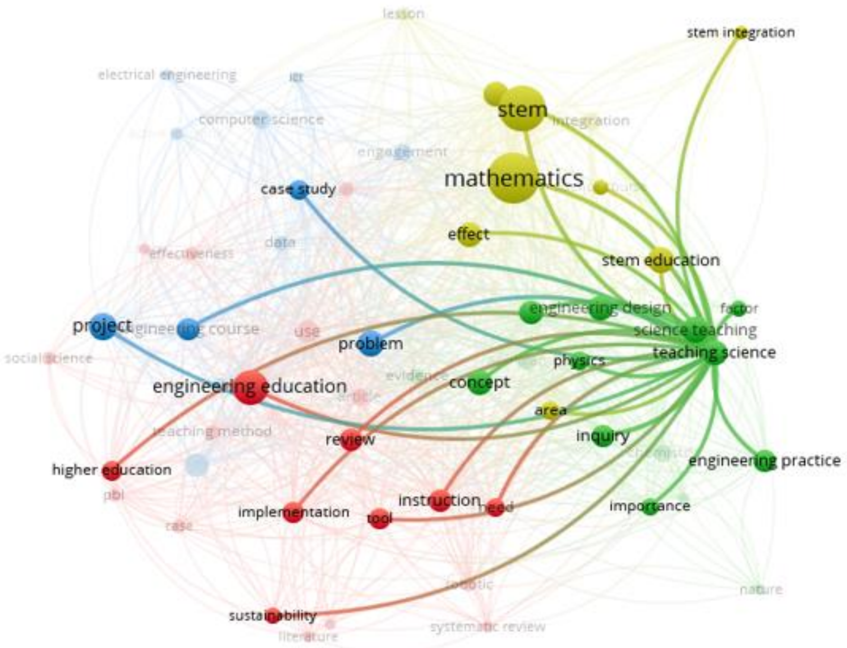

Figure 4. Network visualization of cluster 2.

Cluster 3, which is marked in blue, consists of 12 items, namely active learning, assessment, biology, chemistry, concept, engineering design, engineering practice, evidence, factor, case study, computer science, data, electrical engineering, engagement, engineering course, engineering student, ICT, problem, and project. Based on **Figure 5**, “project” is the main node in the cluster.

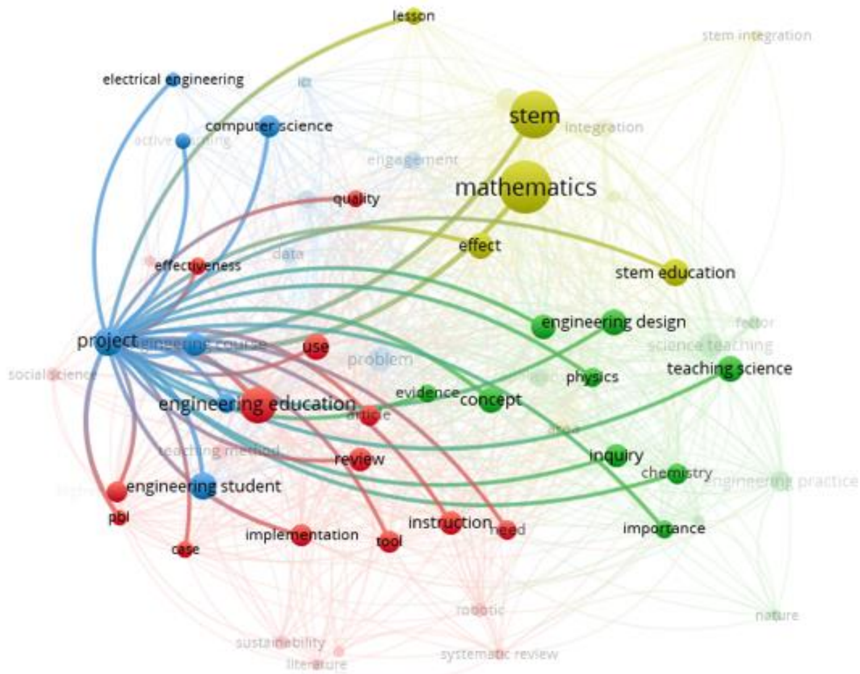

Figure 6. Network visualization of cluster 4.

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Cluster 4, which is marked in yellow, consists of 10 items, namely effect, integration, lesson, math, mathematics, science course, stem, stem education, and stem integration. Based on **Figure 6**, "mathematics" is the main node in the cluster.

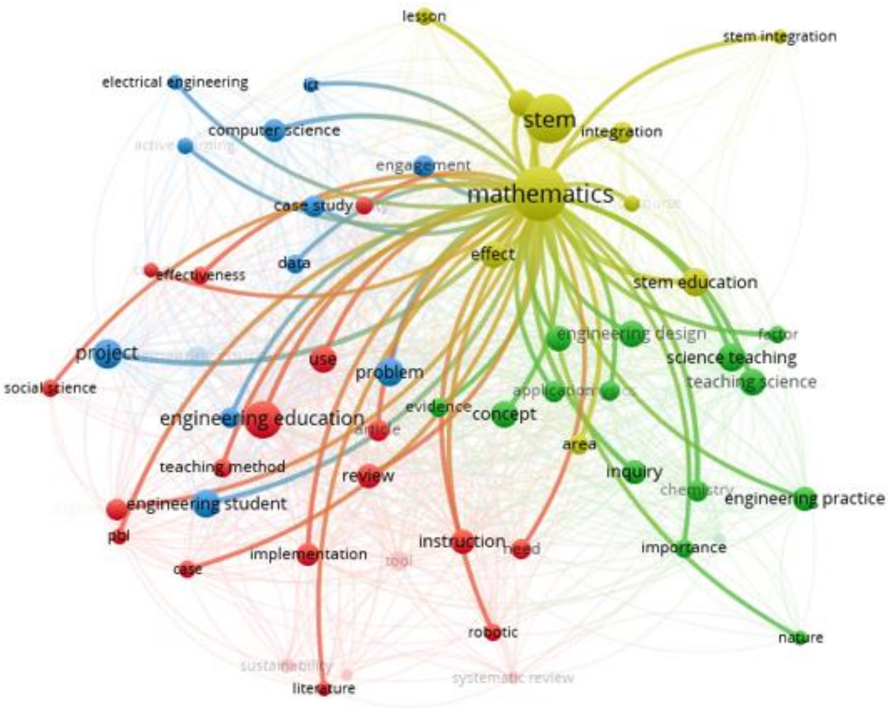

Figure 5. Network visualization of cluster 3.

3.3. Overlay Visualization of Teaching Science Engineering Keyword

Overlay visualization describes the relationship between terms classified according to the research time (Nandiyanto *et al.*, 2021). **Figure 6** depicts research trends in the chemical industry from 2012 to 2021. Based on Figure 6 shows that research on science engineering education was mostly carried out from 2012 to 2017. From the results of the overlay visualization, it shows that the term science engineering education in research has been around for quite a long time. Meanwhile, research on science engineering education has not yet been developed, namely the term covid and effectiveness.

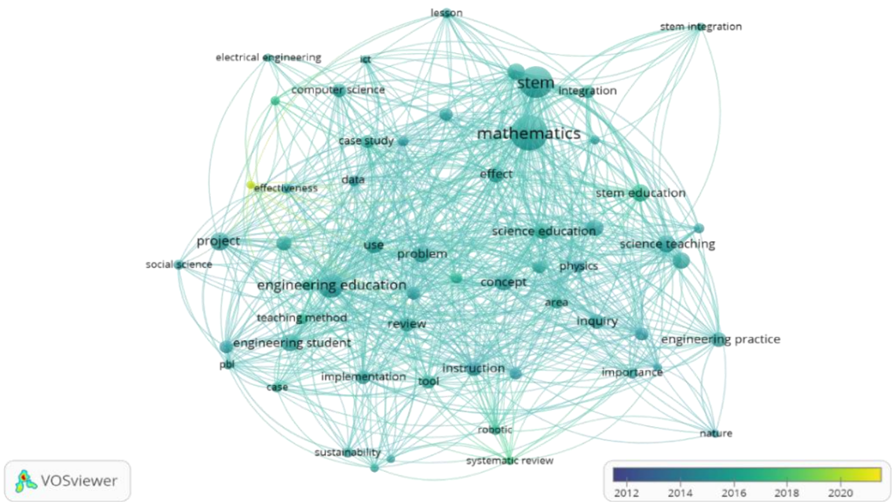

Figure 6. Overlay visualization of teaching science engineering keywords.

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3.4. Density Visualization of Teaching Science Engineering Keyword

Figure 7 is a density visualization that depicts research that is often done based on keywords. Based on the visualization of **Figure 7**, it shows that the more frequently the keywords are used for research, the brighter the yellow color, the larger the diameter of the circle, and the tighter it is. While research with keywords that are slightly marked with faded yellow color. From **Figure 7**, it concluded that several studies are often carried out using keywords stem, mathematics, science teaching, and engineering teaching.

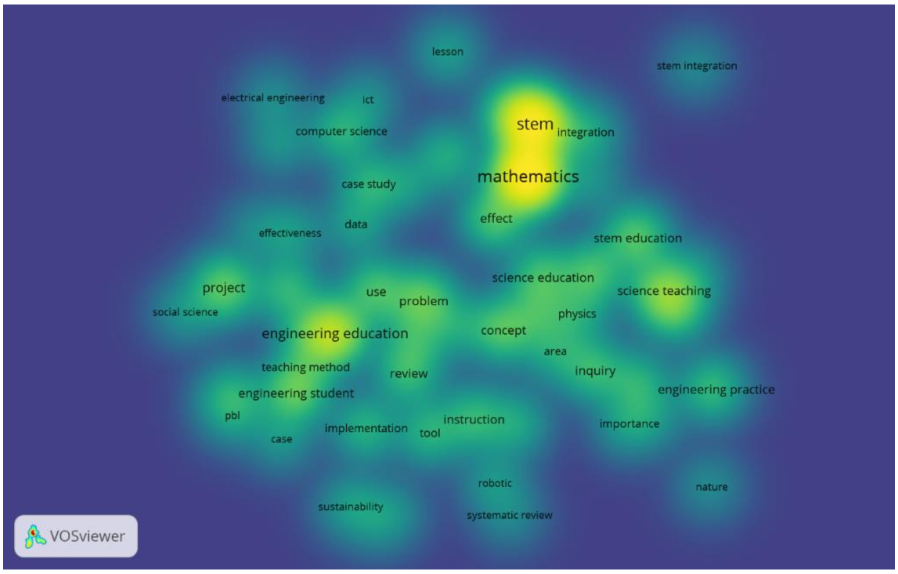

Figure 7. Density visualization of teaching science engineering keywords.

4. CONCLUSION

This study aims to perform computational mapping analysis using bibliometric techniques in the field of teaching science engineering. The articles collected came from the Google Scholar database through the Publish Perish application with the keywords "teaching science engineering. The metadata obtained were 998 articles published from 2012 to 2021. The bibliographic data of this research consisted of titles, topics, keywords, years, publishers, and authors. The results of this study indicate that technical teaching research in 2012-2016 experienced fluctuating changes and from 2017 to 2021 experienced a very significant decline. Based on these results, it shows that teaching science engineering research still has a high enough opportunity to be developed and can also be associated with other terms.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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