Journal of Engineering Science and Technology
Vol. 17, No. 2 (2022) 1135 - 1149

BIBLIOMETRIC COMPUTATIONAL MAPPING ANALYSIS OF PUBLICATIONS ON MECHANICAL ENGINEERING EDUCATION USING VOSVIEWER

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Abstract

This study examines the development of mechanical engineering education research through a bibliometric approach to computational mapping analysis using VOSviewer. The article data was obtained from the Google Scholar database using the publish or perish reference manager application. The title and abstract of the article are used to guide the search process by referring to the keyword "Mechanical Engineering Education". 338 articles were found that were considered relevant. The study period used as the study material is the Google Scholar indexed article for the last 10 years (2012 to 2021). The results showed that mechanical engineering education research can be separated into 3 terms: mechanical engineering education, mechanical engineering, and education. The term "Mechanical Engineering Education" is associated with 157 links with a total link strength of 564. The term "Mechanical Engineering" has 213 links with a total link strength of 1036 and the term "Education" has 224 links with a total link strength of 1201. Results of the analysis of the development of engineering education publications machines in the last 10 years show quite frequent fluctuations. In 2012-2014 it decreased from 56 in 2012 to 25 in 2014. Research fluctuations occurred from 2014-2019 (sequentially 25, 34, 26, 39, 33, 40 publications per year). In 2019-2021 there was a decrease in research, namely from the number of 40 studies (2019) to 11 studies (2021). Meanwhile, popular mechanical engineering education research was conducted in 2012, namely 56 studies. We checked how many articles have been published on mechanical engineering education and its relation to problem areas using VOSviewer. This review can serve as a starting point for research related to other materials.

Keywords: Bibliometric, Computational mapping analysis, Mechanical engineering education, VOSviewer.

1. Introduction

Along with the times, education has become a major need for humans to develop their talents and potential to move forward in the future. The field of education has also developed to meet the needs of the times. The field of education that continues to grow and becomes a necessity for technological and industrial development is mechanical engineering. Mechanical Engineering plays a very large role in the industrial era, especially in efforts to develop and engineer efficient industries [1].

Mechanical engineering is the science of engineering the application of physical principles that can be implemented in the analysis, design, manufacture and maintenance of machines. Mechanical engineering education studies mechanical design and construction, production systems, energy conversion and metallurgical science. Mechanical engineering education deepens the ability of several branches of mechanical engineering such as mechanics, kinematics, materials engineering and thermodynamics. The development of society's demands for technology and industry has made the branch of mechanical engineering also experience development [2]. However, in the field of research, it is still uncertain whether the branch of mechanical engineering is still in great demand or not, especially in the field of education research.

There is one analytical technique that can be used to determine the development of research in the field of mechanical engineering education, namely bibliometric analysis. Bibliometric analysis is a form of meta-analysis of research data that can assist researchers in studying bibliographic content and citation analysis from articles published in journals and other scientific papers.

There have been many studies on bibliometric analysis, including bibliometric analysis in economics [3-7], bibliometric analysis in research on chemistry [8, 9] and chemical engineering [10-12], bibliometric analysis in research on materials [13], Vocational school [14], Scientific publications [15], Special Needs Education [16], Publication of Techno-Economic Education [17], Engine performance [18], Dataset portrays decreasing number of scientific publication [19], Application in robotic hand systems [20], Research effectiveness in a subject area among top class universities[21], Educational Research [22], Management bioenergy [23], Magnetite Nanoparticle [24], Nanocrystalline Cellulose Production Research [25], and Nano Metal-Organic Frameworks Synthesis [26].

However, research on computational mapping of bibliometric analysis of published data in the field of mechanical engineering education which has been carried out specifically to determine the development of the research has not been carried out. Especially bibliometric analysis for research in the last 10 years in the period 2012 to 2021 through the VOSviewer application.

Therefore, this research was conducted to carry out computational research on mapping bibliometric analysis of articles indexed by Google Scholar using VOSviewer software. This research was conducted with the hope that it can be a reference for researchers to conduct and determine the research themes to be taken, especially those related to the field of mechanical engineering education.

2. Method

The article data used in this study was based on research from publications that have been published in Google Scholar indexed journals. We selected Google Scholar in this study because the Google Scholar database is an open source. To obtain research data, a manager reference application was used, namely Publish or Perish. Publish or Perish software was used to conduct a literature review on our chosen topic. Detailed information for using and installing the software and step-by-step process for obtaining data is explained in our previous studies [27] and detailed information about library searches in searching for data on Google Scholar is described in a previous study conducted by Azizah et al. [28].

The research was carried out through several stages:

(i) Collection of publication data using the publish or perish application,

(ii) Processing of bibliometric data for articles that had been obtained using the Microsoft Excel application,

(iii) Computational mapping analysis of bibliometric publication data using the VOSviewer application, and

(iv) Analysis of the results of computational mapping analysis.

The article data search on Publish or Perish is used to filter publications using the keyword "Mechanical Engineering Education" based on the publication's title requirements. The papers used were published between the years of 2012 and 2021. All data was obtained in January 2022. The articles that have been collected and match the criteria for this study's analysis were then exported into two file types: research information systems (.ris) and comma separated value format (*.csv). VOSviewer was also be used to visualize and evaluate trends using bibliometric maps. The article data from the source database was then mapped.

VOSviewer was employed to create 3 variations of mapping publications, namely network visualization, density visualization, and overlay visualization based on the network (co-citation) between existing items. When creating a bibliometric map, the keyword frequency was set to be found at least 3 times. Therefore, obtained 271 terms and keywords that are less relevant were removed.

3. Result and Discussion

3.1. Publication data search results

Based on the data search through application reference manager publish or perish from the Google Scholar database, 338 data articles were obtained that met the research criteria. The data was obtained in the form of article metadata consisting of the author's name, title, year, journal name, publisher, number of citations, article links, and related URLs. Table 1 shows some examples of published data used in the VOSviewer analysis of this study. The data samples taken were the 21 best articles that had the highest number of citations. The number of citations from all articles used in this study is 1004, the number of citations per year is 100.40, the number of citations per article is 2.06, the average author in the articles used is 2.46, all articles have an average h-index is 12, and the g-index is 17.

Table 1. Mechanical engineering education publication data.

No.	Authors	Title	Year	Cites	Refs
1	Childs	Engineering freakout	2013	38	[29]
2	Anggraeni et al.	The deployment of drones in sending drugs and patient blood samples COVID-19.	2020	33	[30]
3	Vu et al.	Development orientation for higher education training programme of mechanical engineering in industrial revolution 4. 0: a perspective in Vietnam	2019	32	[31]
4	Kamińska et al.	Virtual reality as a new trend in mechanical and electrical engineering education	2017	31	[32]
5	Wilczynski et al.	Higher education makerspaces and engineering education	2016	30	[33]
6	Kapilan et al.	Virtual laboratory: A boon to the mechanical engineering education during covid-19 pandemic	2021	24	[34]
7	Enelund et al.	Integration of education for sustainable development in the mechanical engineering curriculum	2013	23	[35]
8	Schrlau et al.	Flipping core courses in the undergraduate mechanical engineering curriculum: Heat transfer	2016	23	[36]
9	Kirkpatrick et al.	ASME vision 2030's recommendations for mechanical engineering education	2017	21	[37]
10	Trissan	Analysis of the factors influencing long studies and student achievement index education of mechanical engineering of Palangkaraya University	2015	20	[38]
11	Mavromihales et al.	Game-based learning in mechanical engineering education: Case study of games-based learning application in computer aided design assembly	2019	15	[39]

Table 1. (Continue). Mechanical engineering education publication data.

No.	Authors	Title	Year	Cites	Refs
12	Fagette et al.	Engineering a general education program: Designing mechanical engineering general education courses	2013	15	[40]
13	Stappenbelt	Plagiarism in mechanical engineering education: A comparative study of international and domestic students	2012	13	[41]
14	Islam et al.	Renewable-energy education for mechanical engineering undergraduate students	2012	13	[42]
15	Trissan	Analysis of effect of interests read study motivation and counseling academictostudent achievement index education of mechanical engineering of Palangkaraya University	2016	11	[43]
16	Lee et al.	Design and operation of 3D printing education curriculum in mechanical engineering	2015	10	[44]
17	Llanes et al.	Project-based learning case of study education in automotive mechanical engineering	2018	10	[45]
18	Liu & Baker	A new questionnaire for assessment of a mechanical engineering senior design class	2018	9	[46]
19	Badi et al.	Animation as a problem-solving technique in mechanical engineering education	2013	9	[47]
20	Acakpovi and Nutassey.	Adoption of competency-based education in TVET institutions in Ghana: a case study of Mechanical Engineering Department, Accra Polytechnic	2015	9	[48]

3.2. Research development in the field of mechanical engineering education

Table 2 shows the development of research in the field of Mechanical Engineering Education published in the Google Scholar indexed journal. Based on the data shown in Table 2, it can be seen that the number of researches in Mechanical Engineering Education is 338 articles from 2012-2021. In 2012 there were 56 articles. In 2013 there were 48 articles. In 2014 there were 25 articles. In 2015 there were 34 articles, in 2016 there were 26 articles, in 2017 there were 39 articles, in 2018 there were 33 articles, in 2019 there were 26 articles, and in 2021 there were

11 articles. From the number of publications, it can be seen that research on mechanical engineering education is still relatively rarely studied every year, especially in the last 10 years (2012-2021). Its development is also quite volatile as can be seen clearly in Fig. 1.

Figure 1 shows the development of chemical engineering education research for the last 10 years in the range of 2012 to 2021. Based on Fig. 1, it is known that the development of research related to chemical engineering education has decreased from 2012-2014. This decline can be seen from the number of publications in 2012 as many as 56 to 2014 only 25 publications. The development of mechanical engineering education research also fluctuated from 2014 to 2019, before finally experiencing a drastic decline again in the last 3 years, namely in 2019 as many as 40 articles, 2020 as many as 26 articles, and 2021 as many as 11 articles. The data shows that the popularity of research on mechanical engineering education tends to be unstable and recently, interest in chemical engineering education research has decreased.

Table 2. Development of chemical engineering education research.

Year of Publications	Number of Publications
2012	56.0
2013	48.0
2014	25.0
2015	34.0
2016	26.0
2017	39.0
2018	33.0
2019	40.0
2020	26.0
2021	11.0
Total	338.0
Average	**33.8**

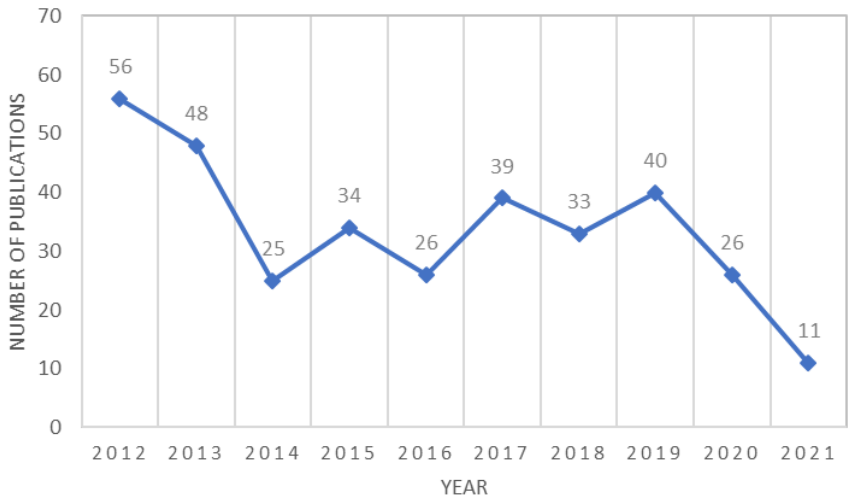

Fig. 1. Level of development in mechanical engineering education research.

3.3. Visualization mechanical engineering education topic area using VOSviewer

Computational mapping was performed on the article data. VOSviewer is used in computational mapping. From the results of computational mapping found 264 items. Each item found related to mechanical engineering education in data mapping is divided into 12 clusters, namely:

(i) Cluster 1 has 51 items and marked in red, the 51 items are achievement, Africa, analysis, article, assessment, case study, change, competence, competency, context, curriculum, demand, development, effect, effectiveness, expectation, faculty, form, game, health, higher education, higher vocational education, humanity, impact, industrial revolution, issue, learning, machine design, mechanical engineering education student, mechanical engineering education study program, mechanical engineering student, mechanism, methodology, order, organization, outcome, perspective, programmer, relevance solution, static, student, study, study program, teacher, technical education, tool, type, undergraduate mechanical engineering education, user, and variety.

(ii) Cluster 2 has 45 items and marked in green, the 45 items are ability, automation, automation specialty, basis, building, center, construction, content, cultivation, education mode, education reform, education system, emerging engineering education, engineering education, engineering education accreditation, engineering education certification, engineering education professional certification, establishment, evaluation, evaluation system, example, experiment, exploration, international perspective, major, manufacturing, mechanical design, mechanical engineering, mechanical majors, mechanical talent, mode, paper, practice, quality, reform, requirement, simulation, standard, status quo, talent, teaching, teaching reform, training, training mode, and universities.

(iii) Cluster 3 has 45 items and marked in blue, the 45 items are Beijing, central south university, Changsha, chemical engineering, China, Chongqing, Chongqing university, civil engineering, college, department, east China university, education, electrical engineering, electronic engineering, engineering, equipment, geotechnical, geotechnical engineering, guanxi university, Guangzhou, institute, key laboratory, laboratory, Lanzhou university, materials science, mechanical, mechanical property, mechanics, ministry, power engineering, school, science, science & technology, shanghai, south China agricultural, south China university, structural safety, technology, Tianjin, Tianjin university, Tongji university, Tsinghua university, underground engineering, university and Wuhan.

(iv) Cluster 4 has 35 items and marked in yellow, the 36 items are additive manufacturing, application, approach, asme vision, cdio, challenge, concept, description, engineering practice, engineering science, experimental learning, focus, future, goal, industry, integrated, integration, knowledge, mechanic, mechanical engineer, mechanical engineering curriculum, mechanical engineering education, mechanical engineering field, mechanical engineering program, mechanical system, need, project, review, role, software, sustainable development, undergraduate student, vision, vocational education, and work.

(v) Cluster 5 has 22 items and marked in purple, the 22 items are case, country, engineering student, enterprise, entrepreneurship education, experience, government, information, information technology, initiative, innovation, part, problem, process, professional education, program psychology, society, strategy, time, way and year.

(vi) Cluster 6 has 17 items and marked in sky blue, the 17 items are characteristic, collaborative, contribution, course, discipline, expert, field, interest, job, journal, mechanical engineering education program, mechanical engineering undergraduate student, observation, research, subject, today, and topic.

(vii) Cluster 7 has 16 items and marked in orange, the 16 items are abstract, comparison, distance education, electrical, energy, environment, fluids education, graduate, institution, master, mechanical engineering, model, remote access laboratory, resource, south Africa, and state university.

(viii) Cluster 8 has 12 items and marked in brown colour, the 12 items are computer, cooperation, creativity, engineer, implementation, information engineering, Jiangsu university, mechanical engineering, skill, soft skill, strength, and structure.

(ix) Cluster 9 has 9 items and marked in pink, the 9 items are automotive engineering, class, engineering research center, gasoline engine, grade, practical skill, principle, process equipment, and Zhejiang university.

(x) Cluster 10 has 7 items and marked in dusty pink, the 7 items is comparative study, factor, level, motivation, overview, Palangkaraya university, and vocational teacher education.

(xi) Cluster 11 has 3 items and marked in light green, the 3 items are clean mechanical manufacture, high efficiency, and Shandong university.

(xii) Cluster 12 has 2 items and marked in light sky blue, there are conference modern engineering and selected contribution.

The relationship between one term and another is shown in each existing cluster. Labels are given to each term with coloured circles. The size of the circle for each term varies depending on the frequency of occurrence of the term [11]. The size of the label circle shows a positive correlation with the occurrence of the term in the title and abstract [13]. The more often the term is found, the larger the label size [27]. The mapping visualization analysed in this study consists of 3 parts: network visualization (see Fig. 2), density visualization (see Fig. 3), and overlay visualization (see Fig. 4) [49].

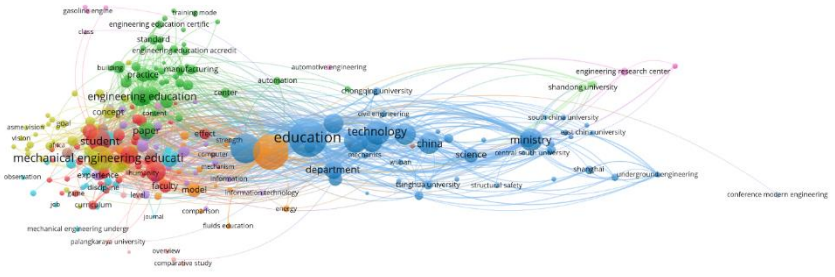

Fig. 2. Network visualization of mechanical engineering education keyword.

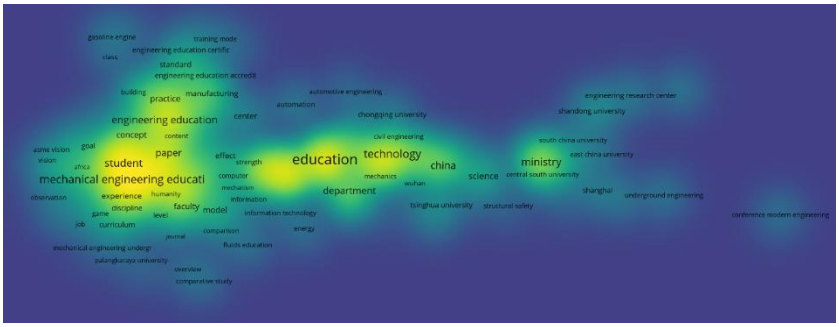

Fig. 3. Density visualization of mechanical engineering education keyword.

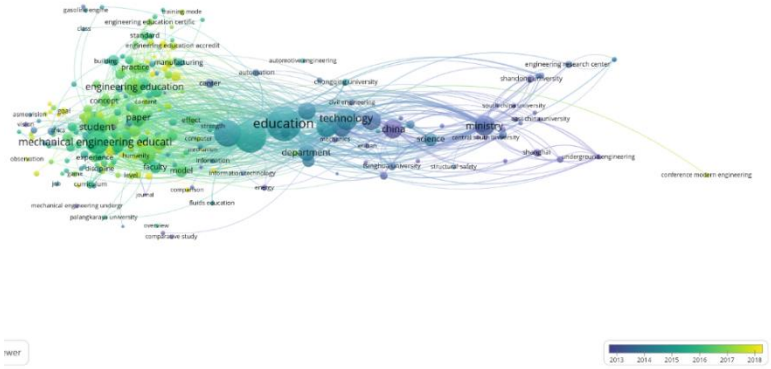

Fig. 4. Overlay visualization of mechanical engineering education keyword.

Figure 2 shows the relationship between terms. The relationship between terms is depicted in an interconnected network. Figure 2 shows the cluster of each term that is often researched and related to the research topic of mechanical engineering education. From the clusters contained in the network visualization, it can be seen that the research on mechanical engineering education can be separated into 3 fields, namely the education term which is included in cluster 3 with 224 links total, 1201 total link strength, and 179 occurrences (see Fig. 5). The second term is mechanical engineering which belongs to cluster 7 with a total of 213 links, a total link strength of 1036, and occurrences of 159 (see Fig. 6), and a mechanical engineering education term which belongs to cluster 4 with a total of 157 links, a total link strength of 564, and 77 occurrences (see Fig. 7).

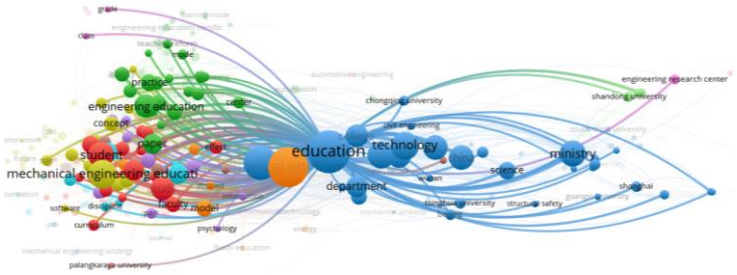

Fig. 5. Network visualization of education term.

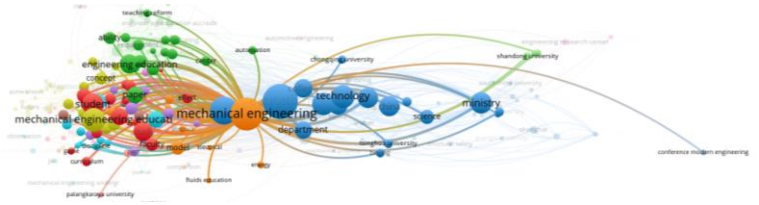

Fig. 6. Network visualization of mechanical engineering term.

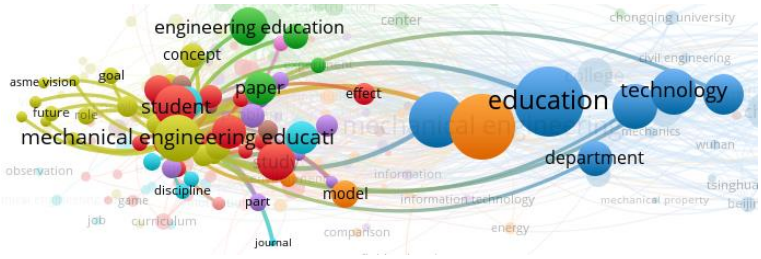

Fig. 7. Network visualization of mechanical engineering education term.

Figure 3 shows the density visualization. Density visualization means that the brighter the yellow colour and the larger the diameter of the circle of term labels, the more often the term appears [11, 13, 15, 36]. This means that a lot of research on related terms has been carried out. Vice versa, if the colour of the term fades closes to the background colour, then the number of studies on the term is small. Based on Fig. 3, it can be seen that research related to the terms, education, technology, mechanical engineering education, student, and engineering education has a high number of studies.

Figure 4 shows the overlay visualization in mechanical engineering education research. This visualization overlay shows the novelty of research on related terms [11, 13, 27, 49]. Figure 4, which is clarified in Fig. 8, shows that research on mechanical engineering education was mostly carried out from 2015 to 2016. The time for the popularity of the term mechanical engineering education in research has been quite long. Thus, we can easily create new research on mechanical engineering education.

Figure 5 shows a network of educational relations with other terms, namely departments, technology, civil engineering, changing universities, Wuhan, Tsinghua University, Beijing science, structural safety, ministry, shanghai, Shandong university, engineering research center, psychology, information, model, Palangkaraya University, sections, faculties, curriculum, disciplines, software, mechanical engineering education, papers, students, effects, concepts, engineering education, centres, fashions, practices, classes, and classes. Figure 6 shows the network of relationships between mechanical engineering terms and existing terms, including modern engineering conference, Shandong university, ministry, science, Tsinghua University, Beijing, China, department, technology, Chongqing University, energy, fluid education, electricity, model, faculty, sections, abstracts, Palangkaraya university, curriculum, disciplines, games, students, papers, concepts, engineering education, centres, automation, abilities, requirements, and teaching reform. While Fig. 7 shows a network of mechanical engineering

education relationships, which are connected with the terms, education, majors, technology, engineering education, effects, models, concepts, disciplines, future, goals, asthma vision, roles, sections, journals, and studies.

From these data, it can be seen that mechanical engineering education is still slightly associated with other terms. From the mapping results, mechanical engineering education only has 157 links and is connected to 15 terms. In contrast to the fields of mechanical engineering and education, which tend to have a high degree of relevance and are often associated with various terms. It can be concluded that the field of mechanical engineering is still very likely to be researched and associated with other terms, this will have a higher impact on research novelty.

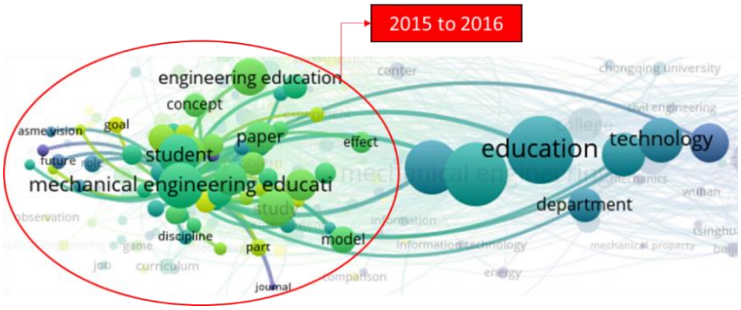

Fig. 8. Overlay visualization of mechanical engineering education term in 2015 to 2016.

Based on the results of the mapping of the collected article data, it can be seen that the keywords mechanical engineering education are still rarely used in research. Most studies only use terms or related fields of mechanical engineering, education, and engineering education. From the results of this study, we can look for research on mechanical engineering education that is more recent and up to date.

4. Conclusion

The purpose of this study was to perform computational mapping analysis on the bibliometric data of research articles. The publication theme taken in this research is "Mechanical Engineering Education". The articles used are taken from the Google Scholar database via Publish or Perish. The library data used in this study include titles and abstracts. From the search results, as many as 338 relevant articles were published in the range of 2012 to 2021. The results showed that mechanical engineering education research experienced a decline from 2012 to 2014, experiencing research fluctuations from 2014 to 2019, and experiencing a decline again in 2019 to 2021. The results of the study indicate that the opportunity for research on mechanical engineering education still has a high enough chance and is linked to other terms.

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