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Bibliometric Computational Mapping Analysis of Publications on Environmental Science-Based Product Design using VOSviewer

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ABSTRACT

This research aims to determine the development of research related to environmental science-based product design and to examine the relationship between terms used in published research. Bibliometrics with computational mapping analysis using the VOSviewer application is used to determine developments and relationships between terms for literature reviews. The information obtained was filtered using Publish or Perish, and article information was obtained from the Google Scholar database. The keyword "environmental science-based product design" is included in the title and abstract of the article to direct the search process. A total of 888 relevant articles are gathered. The research material consists of scholarly papers that have been indexed by Google Scholar in the recent five years (2018-2023). According to the findings, environmental science-based product design research can be classified into two: environmental science and product design. The phrase "environmental science-based product design" has 324 links out of 1108 total. The term "environmental science" has eight connections totalling 29 links, whereas "product design" has eight connections totalling 14 strength links. Analysis of Research and Development Findings Product design based on environmental science has developed over the previous five years. Between 2020 and 2023, the number dropped from 47 in 2020 to 14 in 2023. There was a variation between 2020 and 2023 (47, 35, 49, and 14 releases each year, respectively). Simultaneously, as many as 381 research articles on popular product design based on environmental science were published in 2018. The results of this research show that the terminology used more often is closer to the term environmental science compared to product design. There was also a decrease in the number of publications because, in 2018–2022, due to COVID-19, research related to the science-based product design environment needs to take field data. Several publications have been written regarding environmental science-based product design and its relationship to VOSviewer problem areas. This review can be used as a starting point to learn more about additional terms. This research will have an impact on the development of the number of affinities between terms used in research related to environmental science-based product design.

Keywords:

Bibliometrics; product design; environmental science

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1. Introduction

Bibliometrics is utilized in literature studies to identify research trends and advancements, as well as correlations between terms [1]. In bibliometric analysis, researchers reveal the process of extracting measurable data through statistical analysis of published research, how to use the knowledge available in those publications, and how that knowledge is applied in various research fields to evaluate models from different countries, organizations, journals, authors, and keywords that correspond to specific publication types [2]. Bibliometrics is a quantitative analysis of bibliographic content. It is highly useful for categorizing information depending on a variety of factors, including publications, institutions, and countries [3].

Product design is defined as "a set of features that influence how a product looks, feels, and functions for consumers." Environmental science is the study of the physical environment and the solutions to environmental problems, such as pollution control and environmental degradation, community interaction with the natural environment, and natural resource management. This relates to the education and how to use and protect the environment condition [4-6].

Environmental science-based product design is concerned with planning or manufacturing products to address environmental problems. Bibliometric analysis related to environmental science has been studied [7]. Bibliometric analysis related to environmental science-based product design has also been carried out in [8]. There has not been much written research on the subject. When compared to written publications, research on product design based on environmental science produces more marketable industrial products compared to written publications. Therefore, an analysis was carried out to find out the development of published research related to environmental science-based product design. One of the analytical techniques is bibliometric analysis, which can be used to analyse research developments in the field of environmental science-based product design. Bibliometric analysis is a type of meta-analysis of research data that can assist researchers in reviewing bibliographic data and analysing excerpts from papers published in journals and other scientific publications. Detailed information for the bibliometric is shown in Table 1.

Table 1
 Previous studies on bibliometric

No	Title	Ref.
1	Involving Particle Technology in Computational Fluid Dynamics Research: A Bibliometric Analysis	[9]
2	Bibliometric Computational Mapping Analysis of Trend Metaverse in Education using VOSviewer	[10]
3	The Use of Information Technology and Lifestyle: An Evaluation of Digital Technology Intervention for Improving Physical Activity and Eating Behaviour	[11]
4	Strategies in language education to improve science student understanding during practicum in laboratory: Review and computational bibliometric analysis	[12]
5	How language and technology can improve student learning quality in engineering? definition, factors for enhancing students' comprehension, and computational bibliometric analysis	[13]
6	Mapping of nanotechnology research in animal science: Scientometric analysis	[14]
7	Scientific research trends of flooding stress in plant science and agriculture subject areas (1962-2021)	[15]
8	Introducing ASEAN Journal of Science and Engineering: A bibliometric analysis study	[16]
9	A bibliometric analysis of chemical engineering research using VOSviewer and its correlation with Covid-19 pandemic condition	[17]
10	A bibliometric analysis of materials research in Indonesian journal using VOSviewer	[18]
11	Bibliometric analysis of engineering research using VOSviewer indexed by google scholar	[19]
12	Bibliometric computational mapping analysis of publications on mechanical engineering education using VOSviewer	[20]
13	Research trend on the use of mercury in gold mining: Literature review and bibliometric analysis	[21]

14	Domestic waste (eggshells and banana peels particles) as sustainable and renewable resources for improving resin-based brake pad performance: Bibliometric literature review, techno-economic analysis, dual-sized reinforcing experiments, to comparison with commercial product	[22]
15	Bibliometric analysis of educational research in 2017 to 2021 using VOSviewer: Google scholar indexed research	[23]
16	Corncob-derived sulfonated magnetic solid catalyst synthesis as heterogeneous catalyst in the esterification of waste cooking oil and bibliometric analysis	[24]
17	The complete lextutor application tool for academic and technological lexical learning: Review and bibliometric approach	[25]
18	Use of blockchain technology for the exchange and secure transmission of medical images in the cloud: Systematic review with bibliometric analysis	[26]
19	Computational bibliometric analysis of research on science and Islam with VOSviewer: Scopus database in 2012 to 2022	[27]
20	Digital transformation in special needs education: Computational bibliometrics	[28]
21	Antiangiogenesis activity of Indonesian local black garlic (<i>Allium Sativum</i> 'Solo): Experiments and bibliometric analysis	[29]
22	Characteristics of tamarind seed biochar at different pyrolysis temperatures as waste management strategy: experiments and bibliometric analysis	[30]
23	The complete lextutor application tool for academic and technological lexical learning: Review and bibliometric approach	[31]
24	Corncob-derived sulfonated magnetic solid catalyst synthesis as heterogeneous catalyst in the esterification of waste cooking oil and bibliometric analysis	[32]

A computational mapping study for bibliometric analysis in the field of environmental science-based product design was carried out primarily to uncover unimplemented research developments. The VOSviewer application was utilized specifically for the bibliometric analysis of the last 5 years of research from 2018 to 2023. The VOSviewer application was used in this work to map the bibliometric analysis of publications indexed by Google Scholar. This study was carried out with the intention that it would serve as a resource for academics in developing and choosing research subjects, particularly in the field of environment-based product design. Based on the explanation above, it is necessary to know the development of published research related to environmental science-based product design. The purpose of this research was to determine the development of published research related to environmental science-based product design with terminology that is close to close, often to rarely used as a reference for scientific development.

2. Methodology

The article data used in this study was based on Google Scholar-indexed journal publications. The Google Scholar database was utilized for this investigation since it was free. To gather research data and conduct literature evaluation on specific themes, management reference program Publish or Perish was employed. Detailed information regarding bibliometric is shown elsewhere [33,34]. Here are some of the actions that were taken: Publishing data collection via the publication application:

- i. Processing of article bibliometric data received using the Excel application
- ii. Analysis of bibliometric publication data from the VOSviewer Application computational mapping
- iii. Evaluation of Computer Mapping Analysis Results.

The Publish or Perish article search was used to filter publications between 2018 and 2023 based on publication title using the keywords “product design” and “environmental science”. As of June 2023, all data was restored. Articles that met the study analytic requirements were then exported to

two file formats: research information systems (.ris) and comma-separated value formats (*.csv). VOSviewer was also used to visualize and assess trends through the use of bibliometric maps. The article information was then mapped in the source database. VOSviewer was used to generate three types of mapping output: network visualization, density visualization, and network-based overlay visualization (shared references) between existing sites. Keyword frequency was specified at least three times when creating a bibliometric map. As a result, 45 less important terms and keywords were removed.

3. Results and Discussion

3.1 Publication Data Search Results

888 information articles that fit the research criteria were identified based on information searches in the Google Scholar database that were published or carried out utilizing reference management software. The information gathered is presented in the form of article metadata, which contains the author's name, year, journal name, publisher, reference number, article link, and link URL. Table 2 illustrates an example of published data from this study that was used in the VOSviewer analysis. The sample data included 18 of the most cited articles. There were 2459 citations in total, 804.52 citations per year, 59.7 citations per article, and the average number of authors in the papers used was 3.

Table 2
 Environmental science-based product design

No.	Cites	Authors	Title	Year	Ref
1	360	JE Fargione, S Bassett, T Boucher, SD Bridgham...	Natural climate solutions for the United States	2018	[35]
2	227	M Li, Q Zhang, B Zheng, D Tong, Y Lei...	Persistent growth of anthropogenic non-methane volatile organic compound (NMVOC) emissions in China during 1990–2017: drivers, speciation and ozone ...	2019	[36]
3	125	S Yu, J Lee	The effects of consumers' perceived values on intention to purchase upcycled products	2019	[37]
4	120	Q Jiang, Z Liu, W Liu, T Li, W Cong, H Zhang...	A principal component analysis based three-dimensional sustainability assessment model to evaluate corporate sustainable performance	2018	[38]
5	117	NK Singh, JM Wood, F Karouia...	Succession and persistence of microbial communities and antimicrobial resistance genes associated with International Space Station environmental surfaces	2018	[39]
6	93	Á González-Moreno, Á Triguero...	Many or trusted partners for eco-innovation? The influence of breadth and depth of firms' knowledge network in the food sector	2019	[40]
7	88	R Lukyanenko, A Wiggins, HK Rosser	Citizen science: An information quality research frontier	2020	[41]
8	75	S Waheed, MM Khan, N Ahmad	Product packaging and consumer purchase intentions	2018	[42]
9	73	EB Agyekum, MNS Ansah, KB Afornu	Nuclear energy for sustainable development: SWOT analysis on Ghana's nuclear agenda	2020	[43]
10	59	R Nicastro, P Carillo	Food loss and waste prevention strategies from farm to fork	2021	[44]
11	55	DJ Wrathall, J Devine, B Aguilar-González...	The impacts of cocaine-trafficking on conservation governance in Central America	2020	[45]
12	54	A Kumar, A Nayyar	si3-Industry: A Sustainable, Intelligent, Innovative, Internet-of-Things Industry	2020	[46]
13	54	F Wijen, M Chiroleu-Assouline	Controversy over voluntary environmental standards: A socioeconomic analysis of the Marine Stewardship Council	2019	[47]

14	52	F Quoquab, J Mohammad	A review of sustainable consumption (2000 to 2020): What we know and what we need to know	2020	[48]
15	52	NE Ray, TJ Maguire, AN Al-Haj...	Low greenhouse gas emissions from oyster aquaculture	2019	[49]
16	41	M Rosenberg, K Ilić, K Juganson, A Ivask, M Ahonen...	Potential ecotoxicological effects of antimicrobial surface coatings: a literature survey backed up by analysis of market reports	2019	[50]
17	40	I Galili	Towards a refined depiction of nature of science: applications to physics education	2019	[51]
18	36	BJ Mahler, LH Nowell, MW Sandstrom...	Inclusion of pesticide transformation products is key to estimating pesticide exposures and effects in small US streams	2021	[52]

3.2 Research Development in The Field of Environmental Science-Based Product Design

Table 3 displays research advances in the field of environmental science-based product design that have been published in Google Scholar-indexed publications. According to the data in Table 3, the number of studies in the field of environmental science-based product design is 888 articles from 2018 to 2023. There were 381 papers published in 2018, 362 papers in 2019, 47 articles in 2020, 35 articles in 2021, 49 articles in 2022, and 14 articles in 2023. According to the number of publications, research on environmental science-based product design is still infrequent, particularly in the last three years (2020-2023).

Table 3
 Development of environmental science-based product design

Years	Total
2018	381
2019	362
2020	47
2021	35
2022	49
2023	14

Its development is likewise highly volatile, as illustrated in Figure 1. Figure 1 depicts the evolution of environmental science-based product design research over the last five years, from 2018 to 2023. According to Figure 1, research developments in the environmental science-based product design have decreased between 2020 and 2023. This decline can be seen in the number of publications from 47 in 2020 to 14 in 2023. According to the data, the popularity of research on product design based on environmental science is volatile, and interest in research on product design based on environmental science has lately fallen.

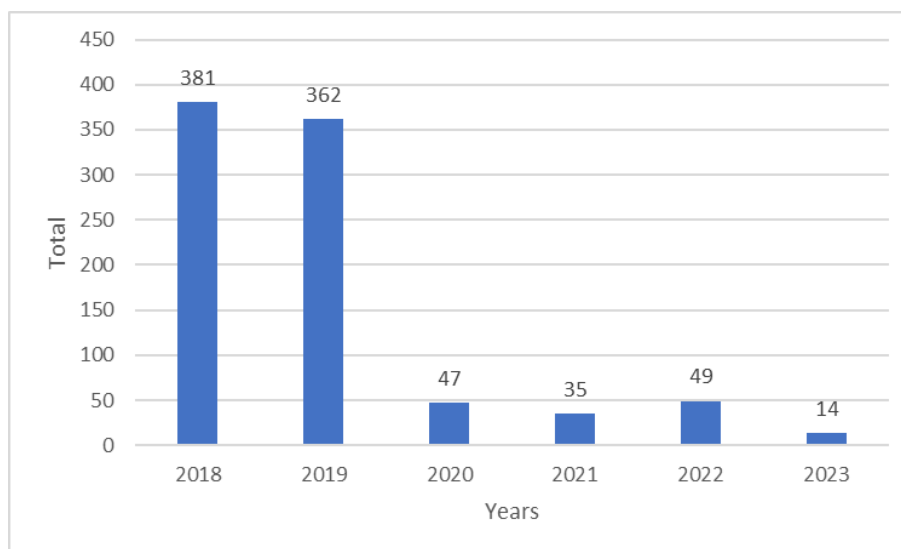


Fig. 1. Level of development in environmental science-based product design

3.3 Visualization Environmental Science-Based Product Design Topic Area using VOSviewer

The article data is subjected to computational mapping through VOSviewer. 45 objects were discovered as a result of the computational mapping. Each item discovered in the data mapping that is connected to environmental science-based product design is grouped into five clusters, namely:

- i. Cluster 1 contains 17 items and is highlighted in red. The 17 items are accumulation, bacterium, field experiment, growth, paddy field, paddy soil, pig manure, pot experiment, remediation, removal, response, rice, rice straw, type, uptake, wheat, and yield.
- ii. Cluster 2 contains 11 items and is highlighted in green. The 11 items are area, case study, characteristic, content, distribution, evaluation, farmland, farmland soil, risk assessment, sediment, and soil sample.
- iii. Cluster 3 contains 9 items and is highlighted in blue. The 9 items are development, environment science, fact, product, product design, review, science, service, and sustainable development.
- iv. Cluster 4 contains 5 items and is highlighted in yellow. The 5 items are descriptive purpose, firm, product name, trade, and use.
- v. Cluster 5 contains 3 items and is highlighted in purple. The 3 items are adsorption, agro-environment science, and product support.

Each existing cluster depicts the relationship between one object and another. Each phrase is denoted by a coloured circle. The size of the circle for each term varies according to its frequency of occurrence [18]. The size of the circle label correlates positively with the presence of the term in the title and abstract. The greater the circle size, the more frequently the word is found [17]. This study's map visualization is divided into three parts: network visualization (see Figure 2), density visualization (see Figure 3), and overlay visualization (see Figure 4).

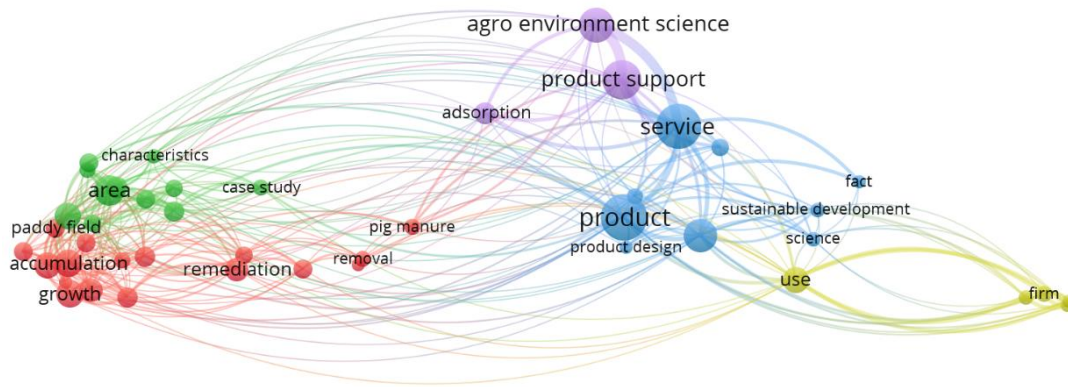


Fig. 2. Network visualization of environmental science-based product design keyword

The size of the nodes or circles reflect the keyword frequency, namely the higher the keyword frequency, the larger the node size. The line thickness is proportional to the closeness of the connection between the two keywords. A thicker line between two words means there is a closer relationship [1].

The link between terms is depicted in Figure 2. An interconnected network describes the relationships between terms. Figure 2 depicts the clusters of each phrase that are often explored and associated to subjects in environmental science-based product design research. The network visualization shows that research on environmental science-based product design can be divided into two fields, with environmental science terms included in cluster 3 with a total of 8 links, 29 total link strengths, and 18 occurrences (see Figure 5). The second term is a cluster 3 product design with a total of 8 linkages, 14 link strengths, and 11 occurrences (see Figure 6).

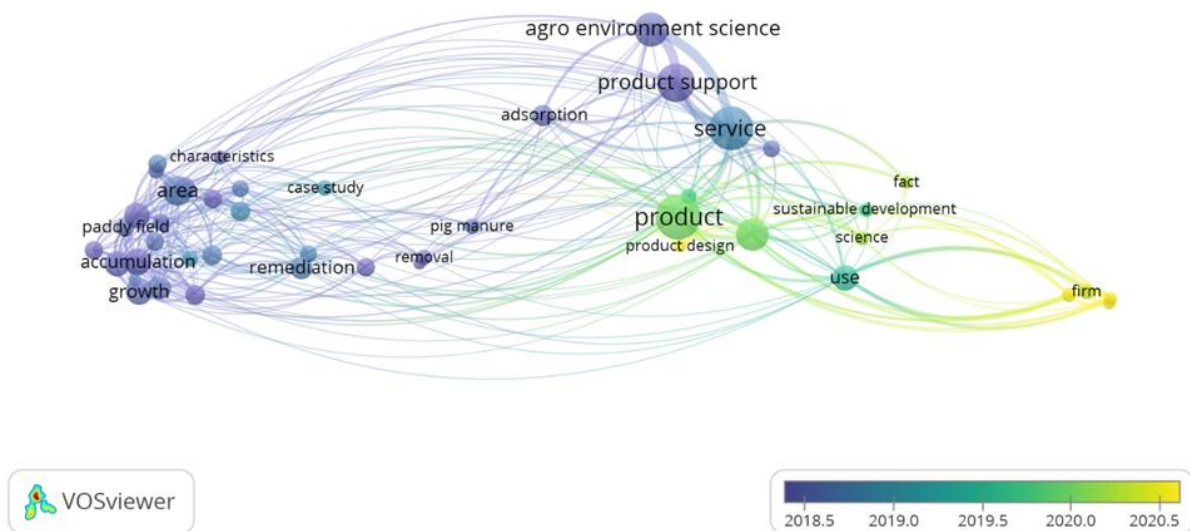


Fig. 3. Overlay visualization of environmental science-based product design keyword

The density visualization is shown in Figure 4. Density visualization signifies that the more frequently the phrase occurs, the brighter the yellow hue and the greater the circle diameter of the term label. This suggests that there has been a significant amount of research on linked keywords [53]. If the term's colour fades toward the background colour, the quantity of studies on the term is low. Figure 4 shows that studies on terms of accumulation, growth, and product include a large number of studies [54].

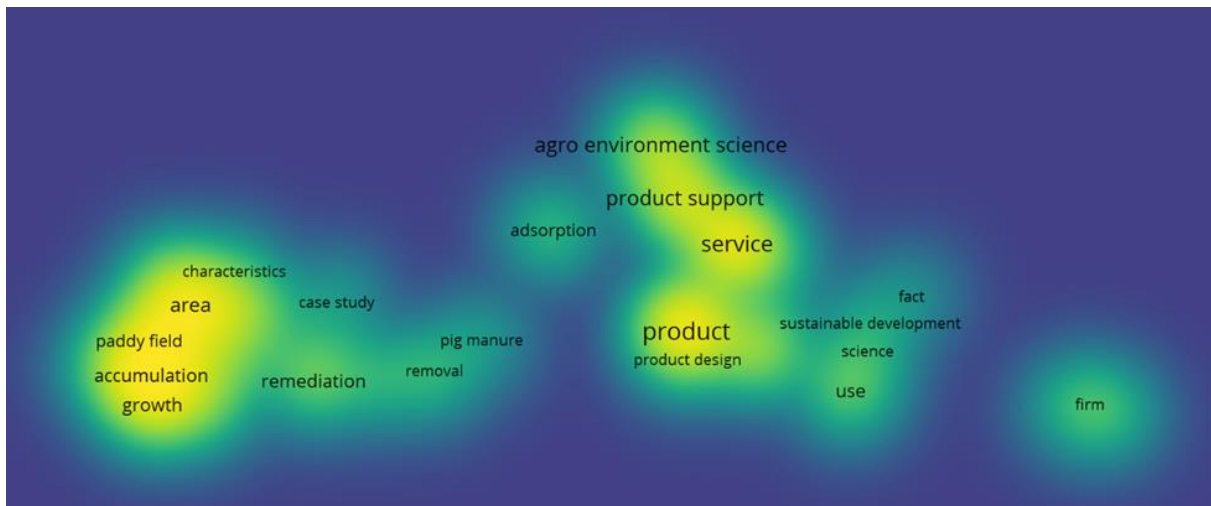


Fig. 4. Density visualization of environmental science-based product design keyword

Figure 5 shows an overlay visualization of environmental science-based product design research. It shows the novelty of research on related terms. From these data, it can be seen that environmental science-based product design is still somewhat related to other terms. From the mapping results, the field of product design only has 8 links and is connected with 14 terms. The field of environmental science tends to have a high degree of relevance and is often associated with various terms. It can be concluded that the field of product design is still very likely to be researched and related to other terms; this will have a higher impact on research novelty.

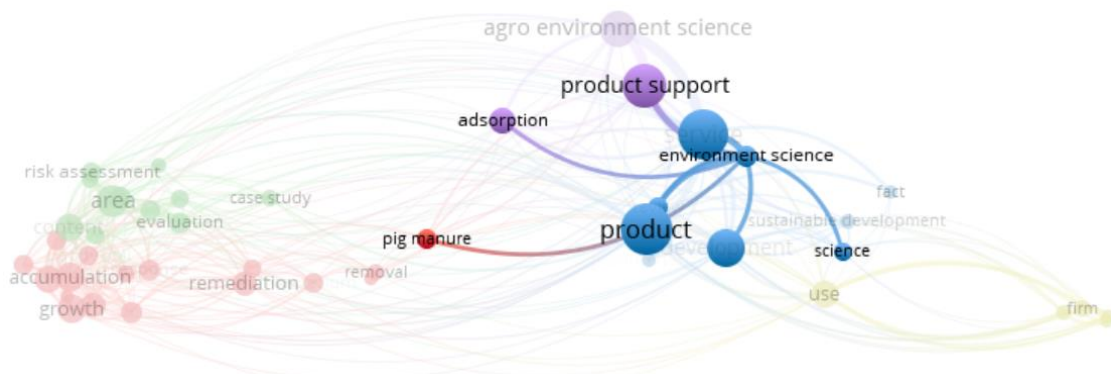


Fig. 5. Network visualization of environmental science term

According to the mapping results of the obtained article data, the keyword product design based on environmental science are seldom used for research. The majority of research only employs terms or disciplines linked to environmental science. According to the findings of this study, recent environmental science-based product design research follows environmental challenges that are now occurring in our immediate surroundings. This study gives information for further development as reported elsewhere regarding several subjects:

- i. Mathematics [55-82]
- ii. Biology [83-92]
- iii. Physics [93-97]
- iv. Chemistry [98-104]
- v. Engineering [105-110]

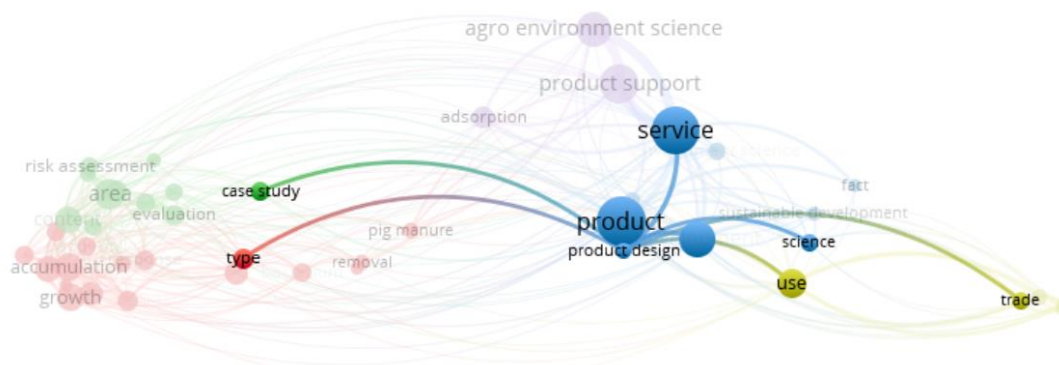


Fig. 6. Network visualization of product design term

4. Conclusions

The goal of this study is to run a computational mapping analysis on bibliometric data from research publications. "Environmental Science-Based Product Design" is the publishing theme chosen for this study. The articles utilized were from the Google Scholar Database and were obtained through Publish or Perish. The titles and abstracts from the library data were used in this study. The search results revealed a total of 888 relevant articles published between 2018 and 2023. According to the findings, environmental science-based product design research has declined between 2020 and 2023. The study's findings also indicate that the potential for research on environmental science-based product design remains relatively high and is related to other terms. This happens because industries that make product designs based on environmental science are mostly formulated in the form of industrial products that are ready to be marketed compared to written publications.

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