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Computational Bibliometric Analysis on Publication of Techno-Economic Education

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ABSTRACTS

Techno-economics involves the systematic evaluation of economic aspects in order to provide solutions to technical problems encountered. The study of techno-economics can provide a basis for decision making related to economic factors. This study was to analysed the scope of research on techno-economic education using bibliometric evaluation and data mapping approach (i.e., VOSviewer software). Material research data was gathered from application reference manager databases. The study material titles, keywords, and abstracts are used to guide the search process. In the period 2017-2022, the analysis was conducted using the number of publications collected, which totalled 288 related papers. Based on the number of publications related to techno-economic educations, the total publications from 2017-2022 are unstable. However, in 2021 publications related to techno-economic education have increased. This study highlights the value of bibliometric analysis in providing information on how phenomena occur. This study is meant to assist and serve as a reference for researchers undertaking and deciding on research topics.

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1. INTRODUCTION

The development of the chemical industry is increasingly complex. And, these developments need to be compared with the state of the natural resources, environmental, and safety aspects of the chemical industry, as well as consumer needs (Surya, *et al*., 2021; Mahmud, *et al*., 2021). Given the limitations of these aspects, an economic evaluation is needed in designing the required industry or market (de Oliveira, *et al*., 2018). Of course, in techno-economic analysis requires good basic skills to be able to win the competition in the industrial world (Buchner, *et al*., 2018; Corderi, *et al*., 2021). Furthermore, this study discovered that examining economic potentials and profitability could provide important information for decision-making about the possibility of scaling up chemical processes and bioprocesses, based on published investigations. Economic performance is one of the most important factors to consider when designing chemical processes (Meramo-Hurtado, *et al*., 2020; Carvajal, *et al*., 2016; Panjapakkul & El-Halwagi, 2018).

In our previous study related to the analysis of techno-economic education in the field of chemistry have been carried out including on waste materials (Nandiyanto, *et al*., 2020; Nandiyanto, 2018), organic materials (Elia, *et al*., 2021), inorganic materials (Nandiyanto, 2021; Zen, *et al*., 2021; Ragadhita, *et al*., 2019; Prabowo, *et al*., 2018; Shalahuddin, *et al*., 2019), and brakepad materials (Nandiyanto, *et al*., 2021). Based on this research, there have been many studies discussing techno-economic education. However, there are no studies that discuss bibliometric analysis and mapping processes using VOSviewer. Therefore, this analysis is important to determine the quantity and up-to-date of a term.

Based on our earlier bibliometric research (Nandiyanto & Al Husaeni, 2021; Al Husaeni & Nandiyanto, 2022), the goal of this work is to combine mapping analysis with VOSviewer software to undertake bibliometric engineering research in techno-economic education. This study is meant to assist and serve as a reference for researchers in performing and deciding on research topics, particularly in the field of chemistry. Bibliometric analysis is thought to be useful at producing datasets that may be utilized to improve research quality (Nandiyanto, *et al*., 2020). A distribution of the type of publication, the topic area investigated, the researcher's country of origin, the journal where the article was published, and the language used is displayed on the bibliometric map (Hamidah, *et al*., 2020). However, the bibliometric employed in this study is a distribution that includes the type of publication and the research topic area is published.

2. METHODS

In performing bibliometric data analysis on a particular publication data, we prepare several applications. First, a reference manager application such as Publish or Perish to prepare database sources. This reference manager application is used to collect research data that has been published related to techno-economic topics. Research data from published articles collected and filtered from 2017-2022 where each article has been indexed by Google Schoolar. The keywords used to compile articles were "education", "techno-economic", and "economic evaluation" to gained 288 articles related this topic. The Second, we need an application for data mapping analysis such as VOSviewer. The VOSviewer application is used because it is an open-source application. Then, using the VOSviewer tool, we created bibliometric maps to visualize and analyze trends. We created data mapping articles from prepared database sources. There are three forms of data mapping: network, density, and overlay visualization. The keyword frequency is set as desired when creating a bibliometric map, and irrelevant or less relevant terms are removed. Our earlier investigations

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(Nandiyanto & Al Husaeni, 2021; Al Husaeni & Nandiyanto, 2022; Al Husaeni & Nandiyanto, 2023) provide detailed information about VOSviewer and library quest.

3. RESULTS AND DISCUSSION

3.1. Research Developments in The Field of Techno-Economic Education

Figure 1 shows the development of research related to techno-economic studies over a period of 6 years (from 2017 to 2022). Based on **Figure 1**, the total publications of studies related to techno-economy are unstable each year. The significant increases in total publications on this topic occurred in 2021. The total number of publications in 2017 was 44 articles. Then, there were an addition of 8 articles in 2018 thus the number of articles was 52 articles. In 2019 and 2020, the trend of the total number of publications of this this topic per year is not much different from the trend of 2017 and 2018. In 2019, there was a decrease in the number of articles compared to 2018. The number of articles in 2019 was 46 articles. Then there was an insignificant increase in 2020 where the number of articles became 55 articles. Furthermore, in 2021 a significant increase in the total number of publications per year reach 80 articles. However, in 2022, the articles available are very much different from the previous year, which was only 11 articles. The decrease in the number of publications in 2022 was due to data collection occurring at the beginning of the year, thus there were still few articles available. Based on **Figure 1**, the increase in 2021 was due to the impact of the COVID-19 pandemic. As we know that techno-economics is related to computational experiments, thus during the COVID-19 pandemic, researchers turned to computational-based research due to the COVID-19 epidemic has limited the number of experiments that may be conducted (physical distancing) (Afifah, 2021).

Based on a total of 288 articles on techno-economics, there are 20 articles with the highest number of citations based on search results through the Google Scholar database. **Table 1** shows the order details of the articles with the most citations.

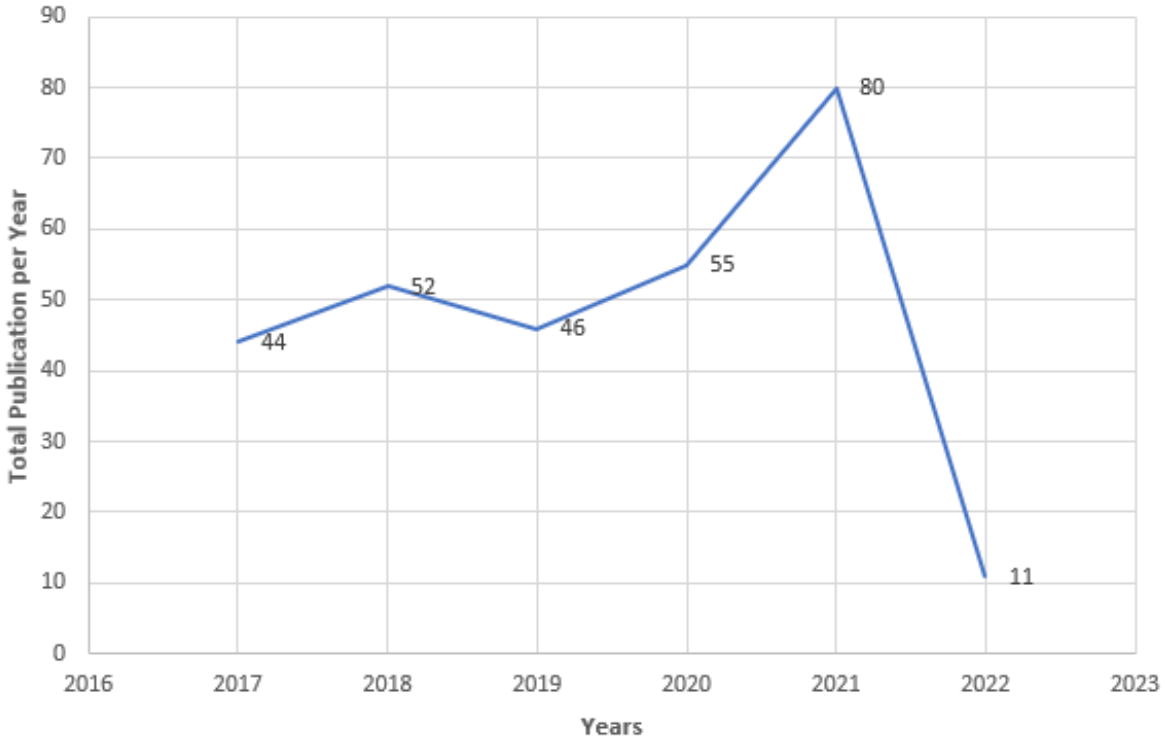

Figure 1. Level development of research on chemical engineering.

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Table 1. List articles with the most citations.

No	Authors	Topic	Journal	Total Citation
1	M Pérez-Fortes et al. (2016)	Methanol synthesis using captured CO_2 as raw material: Techno-economic and environmental assessment	Applied Energy	471
2	B Batidzirai et al. (2013)	Biomass torrefaction technology: Techno-economic status and future prospects	Energy	301
3	M Fasihi et al. (2019)	Techno-economic assessment of CO_2 direct air capture plants	Journal of cleaner production	298
4	A Cherp et al. (2018)	Integrating techno-economic, socio-technical and political perspectives on national energy transitions: A meta-theoretical framework	Energy Research & Social Science	293
5	D Leeson et al. (2017)	A Techno-economic analysis and systematic review of carbon capture and storage (CCS) applied to the iron and steel, cement, oil refining and pulp and steel, cement, oil refining and pulp, and paper industries, as well as other high purity sources	International Journal of Greenhouse Gas Control	289
6	F Fasaei et al. (2018)	Techno-economic evaluation of microalgae harvesting and dewatering systems	Algal Research	236
7	P Collet et al. (2017)	Techno-economic and Life Cycle Assessment of methane production via biogas upgrading and power to gas technology	Applied energy	229
8	J Wang et al. (2018)	Techno-economic challenges of fuel cell commercialization	Engineering	150
9	BK Das et al. (2017)	A techno-economic feasibility of a stand-alone hybrid power generation for remote area application in Bangladesh	Energy	148
10	P Blechinger et al. (2016)	Global analysis of the techno-economic potential of renewable energy hybrid systems on small islands	Energy Policy	132
11	S Dhundhara et al. (2018)	Techno-economic analysis of the lithium-ion and lead-acid battery in microgrid systems	Energy conversion and management	119
12	FG Albrecht et al. (2017)	A standardized methodology for the techno-economic evaluation of alternative fuels–A case study	Fuel	108
13	HA Kazem et al. (2017)	Techno-economic feasibility analysis of 1 MW photovoltaic grid connected system in Oman	Case Studies in Thermal Engineering	98
14	M Qolipour et al. (2017)	Techno-economic feasibility of a photovoltaic-wind power plant construction for electric and hydrogen production: A case study	Renewable and Sustainable Energy Reviews	93

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Table 1 (Continue). List articles with the most citations.

No	Authors	Topic	Journal	Total Citation
15	TL Junqueira et al. (2017)	Techno-economic analysis and climate change impacts of sugarcane biorefineries considering different time horizons	Biotechnology for Biofuels	89
16	A Ahmed et al. (2017)	Environmental life cycle assessment and techno-economic analysis of triboelectric nanogenerators	Energy & Environmental Science	89
17	J Jakobsen et al. (2017)	A techno-economic case study of CO_2 capture, transport and storage chain from a cement plant in Norway	Journal of cleaner production	88
18	V Tomar et al. (2017)	Techno-economic evaluation of grid connected PV system for households with feed in tariff and time of day tariff regulation in New Delhi–A sustainable approach	Renewable and Sustainable Energy Reviews	85
19	C Li et al. (2018)	Techno-economic comparative study of grid-connected PV power systems in five climate zones, China	Energy	85
20	TH Kwan et al. (2018)	Techno-economic analysis of a food waste valorisation process for lactic acid, lactide and poly (lactic acid) production	Journal of cleaner production	82

Based on the **Table 1**, the three articles with the highest number of citations were successively published in the journals Applied Energy, Energy, and the Journal of Cleaner Production.

3.2. VOSviewer Visualization on Techno-Economic Education Topic

The minimum number of relationships between terms in the VOSviewer is restricted by two terms, according to Al Husaeni and Nandiyanto, 2022. Based on the mapping analysis, studies related to technical-economic education are divided into 13 clusters as follows:

(i) Cluster 1 contains 10 items including capital cost, cost, economic benefit, economic indicator, economic model, sensitivity, strategy, techno economic model, techno economic performance, and techno economic viability.

(ii) Cluster 2 contains 9 items consisting of assessment, economic assessment, economic characteristic, economic optimization, economic viability, life cycle analysis, techno economic assessment framework, techno economic case study, and technology.

(iii) Cluster 3 contains 9 items comprising cost estimation, economic analysis, economic information, energy consumption, estimation, framework, rural area, techno economic framework, and techno economic potential.

(iv) Cluster 4 contains 7 items belonging capital, conceptual design, internal rate return, life cycle assessment, net present value, production, and sensitivity analysis.

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(v) Cluster 5 has 7 items including application, economic perspective, education, evaluation, feasibility, techno economic approach, techno economic feasibility evaluation.
(vi) Cluster 6 has 6 items, which consist of Indonesia, techno economic aspect, techno economic feasibility, techno economic optimization, techno economic study, and techno economic analysis.
(vii) Cluster 7 has 5 items, namely current study, economic feasibility, economic potential, education building case study, and techno economic assessment
(viii) Cluster 8 has 5 items, the 5 items are economic analysis model, economic factor, technical analysis, techno economic analysis, and techno economic feasibility.
(ix) Cluster 9 has 4 items, namely environmental impact assessment, investigation, techno, and techno economic evaluation.
(x) Cluster 10 has 4 items consisting economic simulation, energy, techno economic comparison, and techno economic modelling.
(xi) Cluster 11 has 4 items, which consist of case study, economic impact, environmental aspect, and renewable energy source.
(xii) Cluster 12 has 3 items, the 3 items are comprehensive techno economic evaluation, economic, and educational institute.
(xiii) Cluster 13 contains 3 items including economic evaluation, techno economic modelling, and techno economic perspective.

Cluster 1 is red, cluster 2 is marked in green, cluster 3 is marked in dark blue, cluster 4 is yellow, cluster 5 is marked in purple, cluster 6 is light blue, cluster 7 is marked in orange, cluster 8 is marked with brown, cluster 9 is dark yellow, cluster 10 is light red, cluster 11 is marked with light green, cluster 12 is marked in slight blue, and cluster 13 is light purple.

3.3. Network Visualization on Techno-Economic Education Topic

The network between the depicted terms displayed via the visualization network. The link between terms is depicted in **Figure 2**. Relationships in network visualization are depicted by lines connecting one term to another. **Figure 2** shows the clusters in each of the researched topic areas. Based on **Figure 2**, techno-economy eduaction has connections with 13 clusters. **Table 2** summarizes the total strength and occurrence based on techno-economic terms in each cluster.

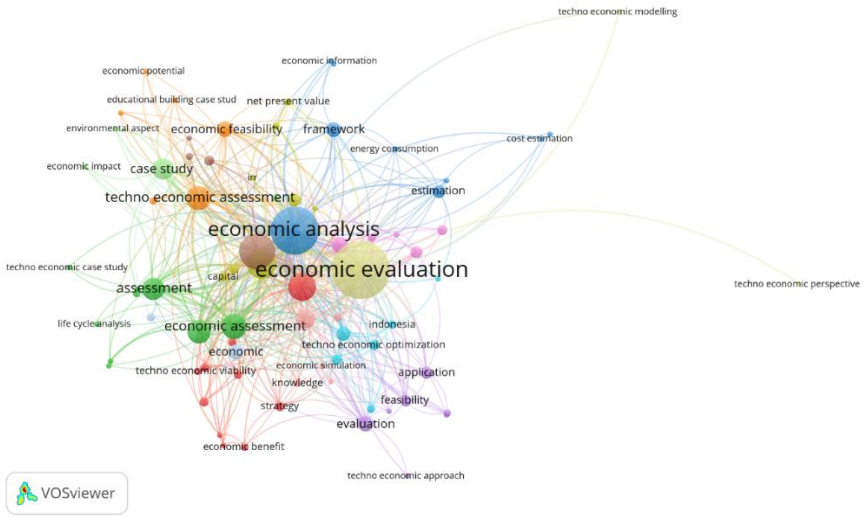

Figure 2. Network visualization on techno-economic education topic.

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Table 2. Total strength and occurrence based on techno-economic term.

Cluster	Total Strength	Occurrence
Cluster 1	109	42
Cluster 2	101	35
Cluster 3	303	123
Cluster 4	138	49
Cluster 5	7	22
Cluster 6	28	11
Cluster 7	94	32
Cluster 8	170	72
Cluster 9	14	3
Cluster 10	22	8
Cluster 11	73	24
Cluster 12	6	1
Cluster 13	389	181

3.4. Density Visualization on Techno-Economic Education Topic

Figure 3 shows the density visualization of research developments on techno-economic topics. Density visualization shows item dots that have a colour that depends on the density of an item (Mulyawati & Ramadhan, 2021). In short, the colour of the dots in the mapping depends on the number of items associated with other items that indicate the most used keywords in the publication. Based on the visualization image (see **Figure 3**), the yellower the colour on the density map, it indicates the closer the relationship. However, the greener the colour is on the density map, it shows a sparse relationship.

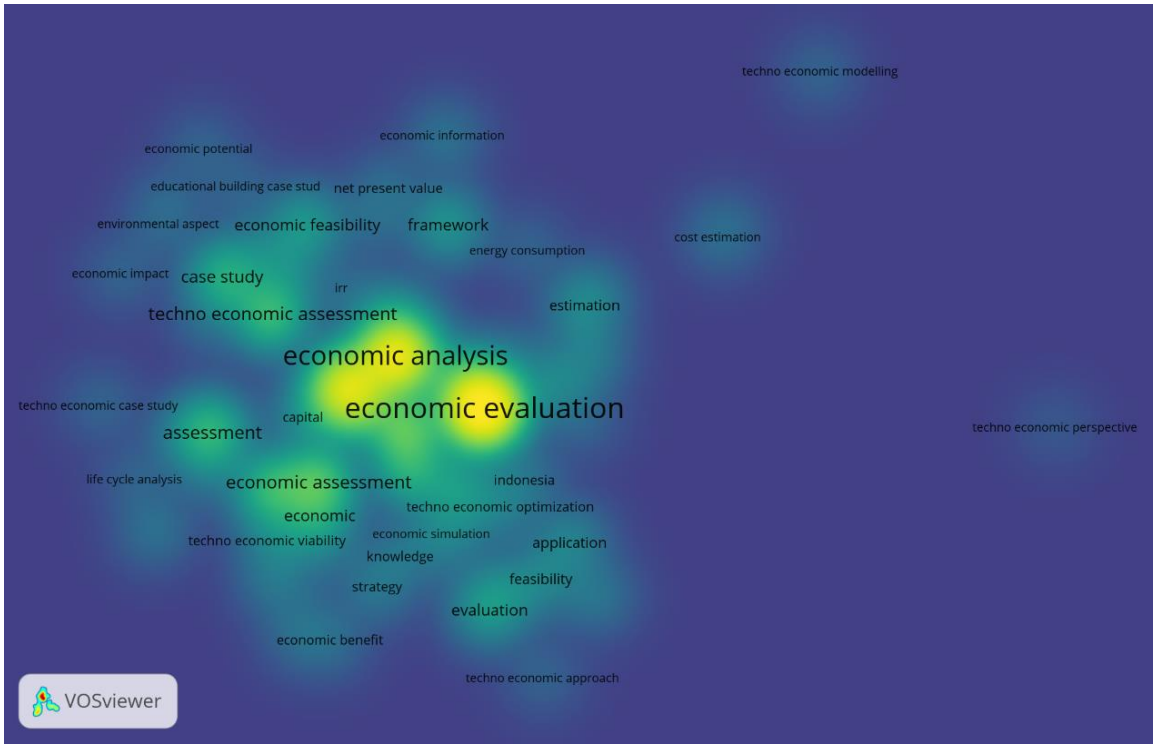

Figure 3. Density mapping on techno-economic education topic.

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4. CONCLUSION

By integrating mapping analysis with VOSviewer software, this study seeks to undertake bibliometric in techno-economic issues. The references manager tool Publish or Perish was utilized to collect data for this study. The information collected was filtered using the keywords "techno-economic," "education," and "economic evaluation." Topic areas, titles, keywords, and abstracts were among the bibliographic data used in this study. We found 288 relevant articles published between 2017 and 2021 based on the search results. In this study, it can be seen that the number of articles about techno-economic is very small per each year, no more than 60 articles per year. Publications on techno-economics in 2021 are the most publications with 80 articles. This is related to the pandemic period, which has made many researchers turn to computational-based research, including techno-economics. Because there are still relatively few studies on techno-economics, this study on techno-economics has the potential to be studied.

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6. AUTHORS' NOTE

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

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