Pedagonal : Jurnal Ilmiah Pendidikan
Vol. 08, No. 02, October 2024, pp. 177~187
ISSN: 2550-0406, DOI: 10.55215/pedagonal.v8i2.19

How does Low-Carbon Education Developed in Indonesia? Bibliometric Analysis

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Article Info

Article history:

Received Jun 9, 2022
Revised Apr 20, 2024
Accepted Apr 25, 2024

Keywords:

Low Carbon
Education
Engineering Education
Bibliometric Analysis

ABSTRACT

The increasing urgency of climate change necessitates a transformative approach to education that integrates sustainability into curricula. Low-Carbon Education (LCE) emerges as a vital framework aimed at fostering awareness and actions that contribute to reducing carbon emissions. This paper aims to explore the trend of low-carbon education in the world particularly in Indonesia, explore its current implementation possibilities, and identify strategies to improve its effectiveness in promoting a sustainable future. This research used bibliometric analysis which is systematic study employing statistical methods to examine bibliographic data. The first step is defining the research objective which consist of trend of low-carbon education in the world particularly in Indonesia, those research objective needs the data of author, citation, country in the publication pertaining low carbon education. Then search the article as data collection from Scopus. In the website Scopus, we search in search document. It found 568 documents. After that, data cleaning and preprocessing by selecting the criteria to meet more results accuracy for low carbon education by selected limit to all open access, by document type: article and conference paper, and range year only 10 years, from 2014-2024. Then the amount of article pertaining low carbon meet 246 documents. This will be proceeded in data analysis process by using a tool, VOSviwer. From that tool, it revealed the results with visualization presentation. The result described that the development of low carbon education research are increase by year and its research still a few in Indonesia, so the researcher has possibility to be researched.

Introduction

The increasing urgency of climate change necessitates a transformative approach to education that integrates sustainability into curricula. Low-Carbon Education (LCE) emerges as a vital framework aimed at fostering awareness and actions that contribute to reducing carbon emissions (Scalabrino *et.al*., 2022; Bazzani, 2023; Rhee *et.al*., 2012; Koo *et.al*., 2014). This concept not only encompasses the teaching of environmental issues but also emphasizes the development of low-carbon behaviors among students, thereby

equipping them with the knowledge and skills necessary for sustainable living (Nurramadhani *et.al*., 2022). Recent studies highlight the current state of LCE in educational settings, revealing significant gaps in its implementation. For instance, a study conducted in Indonesia found that while environmental education is present in curricula, specific low-carbon topics remain underrepresented, indicating a need for more explicit integration of LCE principles in educational materials (Nurramadhani *et.al*., 2022; Hudha, *et.al*., 2021). Furthermore, research suggests that teachers' understanding of LCE varies greatly, impacting how effectively these concepts are communicated to students (Nurramadhani *et.al*., 2022).

Based on the results of the research, in Indonesia it is still very rare for the concept of low carbon to be applied in education. Indonesia has only explored the low carbon concept in the fields of economics (Djatmika *et.al*., 2023; Papargyropoulou *et.al*., 2015), energy (Siagian *et.al*., 2017; Sambodo *et.al*., 2022), architecture (Nugrahanti *et.al*, 2020; Agustiningtyas *et.al*., 2023), agriculture (Fawzi *et.al*., 2024; Prastiyo *et.al*., 2020), and forestry (Aulia *et.al*., 2023; Hairiah *et.al*., 2020). In fact, if Indonesia wants to achieve net zero emission, then the mindset of the community regarding what low carbon is must be strengthened. One way to change people's views and mindsets is through education. Education provides massive insight into a concept from pre-school to university. The most effective way is to incorporate low carbon concepts into the learning curriculum (Date-Huxtable *et.al*., 2013; McGibbon & Van Belle, 2013; Stevenson & Kwok, 2020). Learning that emphasizes a practice of solving environmental problems around them based on the concept of low carbon. This will be able to change the mindset of the community because they have received implementation, knowledge, and trained in 21st century skills that are useful for solving real problems in their environment based on the low carbon concept (Amran *et.al*., 2019; Mitarlis *et.al*., 2017; Nissim *et.al*., 2016).

The role of educational institutions is crucial in this context; they serve as platforms for cultivating environmentally responsible citizens. By embedding low-carbon principles into their teaching practices and curricula, schools can significantly influence students' environmental literacy and behavioral changes towards sustainability (Hudha *et.al*., 2020). Therefore, this paper aims to explore the trend of low-carbon education in the world particularly in Indonesia, explore its current implementation possibilities, and identify strategies to improve its effectiveness in promoting a sustainable future. This paper has significance as the main foundation for the development of low-carbon education in both primary and higher education in Indonesia.

Method

This research used bibliometric analysis which is systematic study employing statistical methods to examine bibliographic data, primarily in scientific and library and information science contexts. It involves analyzing publications to identify patterns, trends, and impact within a specific field or research area (Passas, 2024; Alsharif *et.al*., 2020). This method is used to track author or researcher output and impact, aiding in promotion and tenure decisions as well as funding applications (Donthu *et.al*., 2021).

The first step is defining the research objective which consist of trend of low-carbon education in the world particularly in Indonesia, explore its current implementation possibilities, and identify strategies to improve its effectiveness in promoting a sustainable future. Those research objective needs the data of author, citation, country in the publication pertaining low carbon education. Then search the article as data collection from Scopus. In the website Scopus, we search in search document as “low carbon” and “education”. It found

568 documents. After that, data cleaning and preprocessing by selecting the criteria to meet more results accuracy for low carbon education by selected limit to all open access, by document type: article and conference paper, and range year only 10 years, from 2014-2024. Then the amount of article pertaining low carbon meet 246 documents. This will be proceeded in data analysis process by using a tool, VOSviwer. From that tool, it revealed the results with visualization presentation. Then, interpreted the visualization for reporting steps. The process of bibliometric analysis in this research are shown as Figure 1 below.

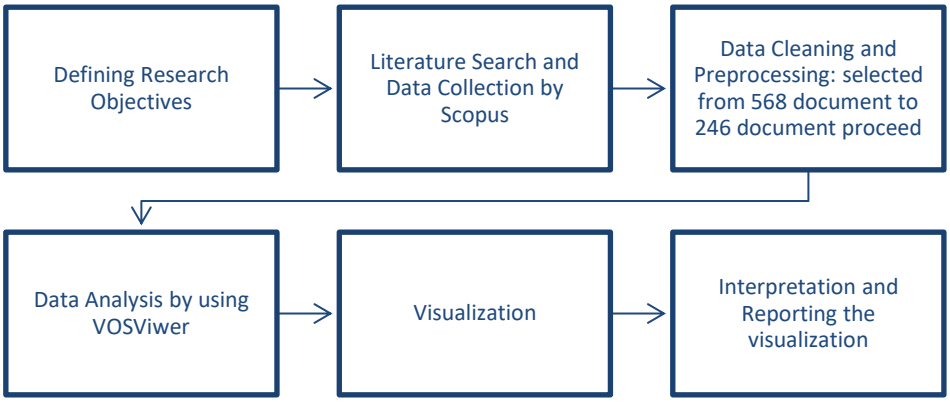

Figure 1. Bibliometric Analysis Process for Low Carbon Education

Results and Discussion

After analyzing 246 documents related to low carbon education in the VOSviwer application, the results of the visualization analysis illustrate how research opportunities related to low carbon education in the world, especially in Indonesia. Who and which countries have the most discussions related to low carbon education, especially research that is widely cited. What keywords are most interrelated with each other and low carbon. Does education have a big connection and what other keywords could pave the way for low carbon research to developed and be implemented in learning activities? The following are the findings of researchers in the world, especially in Indonesia. Figure 2 shown the number of documents that released pertaining low carbon in education by country from 2014 until 2024. From the graph, it could be described that document publication pertaining low carbon in education mostly from China. China has already done positive research pertaining low carbon especially in education area (Li *et.al*., 2022; Zheng *et.al*., 2021). Then it is followed by United Kingdom (Yadoo *et.al*., 2011; Williams & Love, 2022) and United State of America (Lester *et.al*., 2011; Fragkos *et.al*., 2021). Both countries have already concerned about low carbon action and research since 2011. And where is Indonesian position in the amount of low carbon education document publication? Indonesian position is in the 6th rank from below after Sweden, Austria, France, Greece, and Iran. It reveals that, there is still lack of attention and focus to develop low carbon immersed in education curricula. Indonesia still focused to develop low carbon concept in economy, marine and fishery, farm industry, and trade market area.

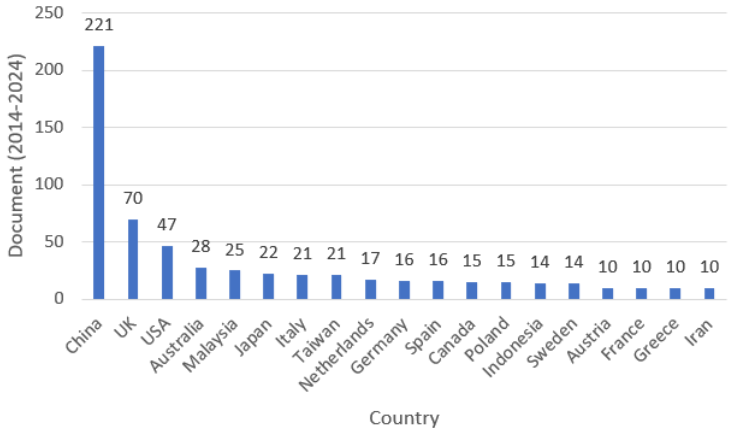

Figure 2. Document Publication in Low Carbon Education based on Country

The following of fourteen document from 2014-2024 that has been published from Indonesian Researcher, here they are the findings of researchers in the world, especially in Indonesia with the number of publication documents related to low carbon education shown in Figure 3 below.

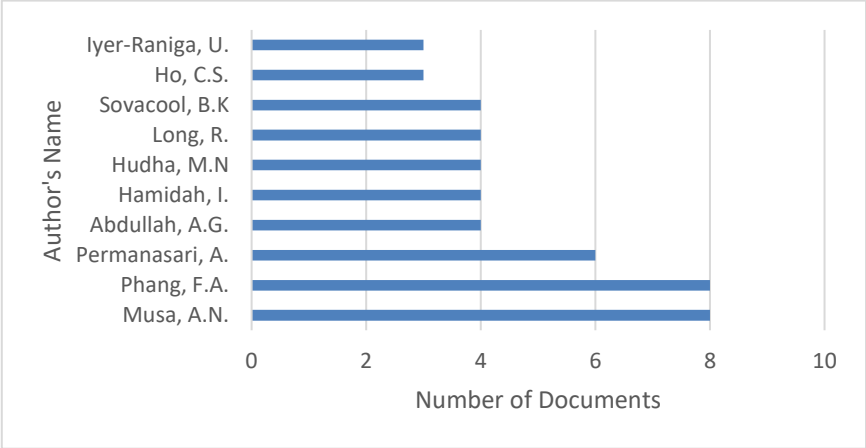

Figure 3. Researcher with Document Publication in Low Carbon Education

Based on figure 3 above, there are already Indonesian researchers researching low-carbon education, for instance Permansari by 6 documents in scopus, Abdullah 3 document in scopus, Hamidah 3 document in scopus, and Hudha 3 document in scopus. This is an opportunity to introduce low-carbon concepts to the public through education. Although these studies are still in the foundation stage related to the concept of low carbon in Indonesia, these efforts can trigger other researchers in Indonesia to be able to take part in studies related to low carbon in education more deeply, even to the point of inserting the concept of low carbon in the curriculum of primary education, secondary education, and higher education.

While, the document of publications also needs the citation as a parameter that research related to low carbon education has been read, understood, and has a significant impact on global and regional researchers, especially in Indonesia. The figure 4 below described pertaining the research has relation with every country that has been published the document. There are large and small circles. a large circle indicates that the number of publications produced by the country is large, while the smaller the circle, the fewer the number of

publications produced. It can be seen that China has the greatest number of research papers among other countries, it also has a network of citations of publication documents or collaboration with various countries in the world for low carbon education research. Examples of countries that have a collaboration and citations with China are USA, Turkey, South Korea, Brazil. While the United Kingdom, which is the second largest producer of publications after China, has collaboration and citations with Iran, Denmark, Italy, Netherland, Poland, Finland which are European countries. Meanwhile, Indonesia in the position has only collaboration and citation with Japan, Malaysia, Canada which both Japan and Malaysia have the greater amount of document publication pertaining low-carbon education from 2014-2024. That shows Indonesian researchers should more focus and consider the concept of low carbon as more than just buying and selling, trade, economics, and maritime. Rather, low carbon is a mindset of the individual that must be developed to achieve the ultimate goal of reducing or eliminating high carbon emission footprints, so that our environment is saved from catastrophic global warming. One of them is to include the role of education in the low carbon theme (Prieler *et.al*., 2022; Zafar *et.al*., 2020).

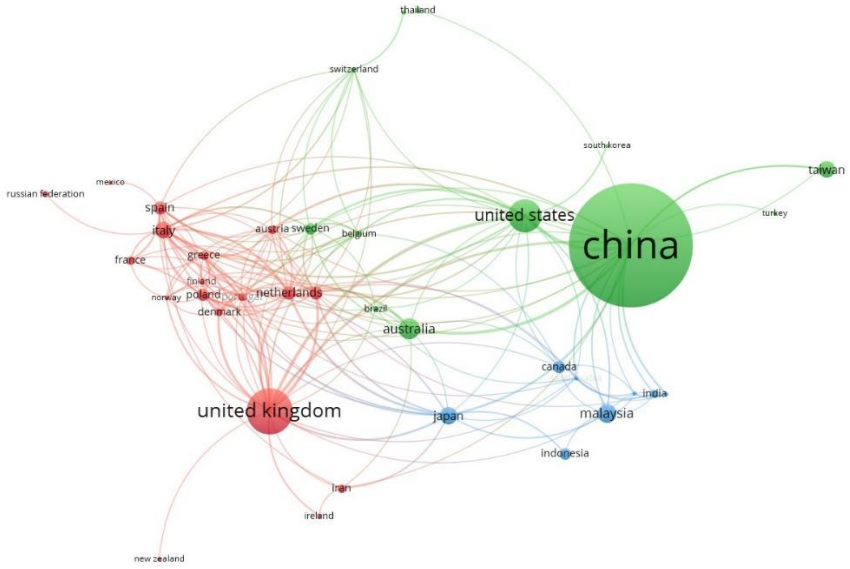

Figure 4. Citation of Document Publication in Low Carbon Education based on Country

Based on the documents that have been selected from Scopus, they are analyzed and visualized using VOSviwer based on keywords. Based on the results of the analysis, there are Four clusters. namely red cluster, blue cluster, green cluster, yellow cluster. The clusters are collected from keyword nodes. The larger the nodes, the more the keyword is used or appears in the publication. Vice versa, the smaller the nodes, the less the keyword appears in the publication. These large nodes represent carbon, sustainable development, education, climate change, and engineering education. The low carbon nodes in green cluster together make a closely connections with education and sustainable development. It could be described that education for sustainable development and low carbon education has strong connection each other. Low carbon education is part of sustainable development education. outside the green cluster, there are climate change and engineering education keywords related to the green cluster. This proves that there is a possibility that low carbon education can be implemented with an engineering education framework and contain climate change material. Engineering education can be implemented with engineering process design (EDP)

activities which are part of the STEM learning approach. So, STEM learning approach is possible to be implemented in low carbon education learning at classroom to develop students' sustainability awareness by making a project as problem solutions. Besides that, by implement STEM learning approach, students should be developing their 21st century skills (Fajrina *et.al*., 2020; Ah-Namand & Osman, 2018; Baran *et.al*., 2021) such as problem-solving skills, critical thinking skills, creativity, collaborations skills, and communications skills to solve real problem pertaining environment-based sustainability concept and low carbon concept (Pramesti *et.al*., 2022; Phang *et.al*., 2016). Topic related to low carbon, education, and engineering education are still topics that need to be discussed and researched in research in the world, especially in Indonesia. The connection of the keywords is figured out in Figure 5 bellow.

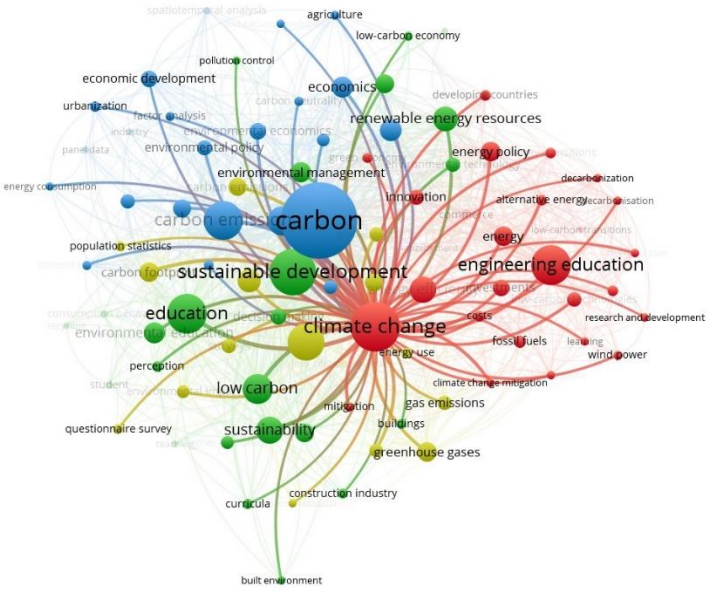

Figure 5. Clustering the Publication of Low Carbon based on Keywords

In addition to showing the number of occurrences and connections between keywords, figure 6 also illustrates the keywords that appear in the most recent and oldest publication years with an overlay visualization. The darker the color (dark blue) the older the publication. The lighter the color (yellow), the more recent the publication. The keyword that has been emerging for a long time from 2019 is education sustainable development. This is exactly four years after the Sustainable Development Goals (SDGs) were issued by the United Nations. As for the topics of low carbon, engineering education, and climate change, these are topics that are still being researched in 2020-2021. With small nodes, it indicates that the topic is still little researched. So, the topic of low carbon is a topic that still needs research and is still new.

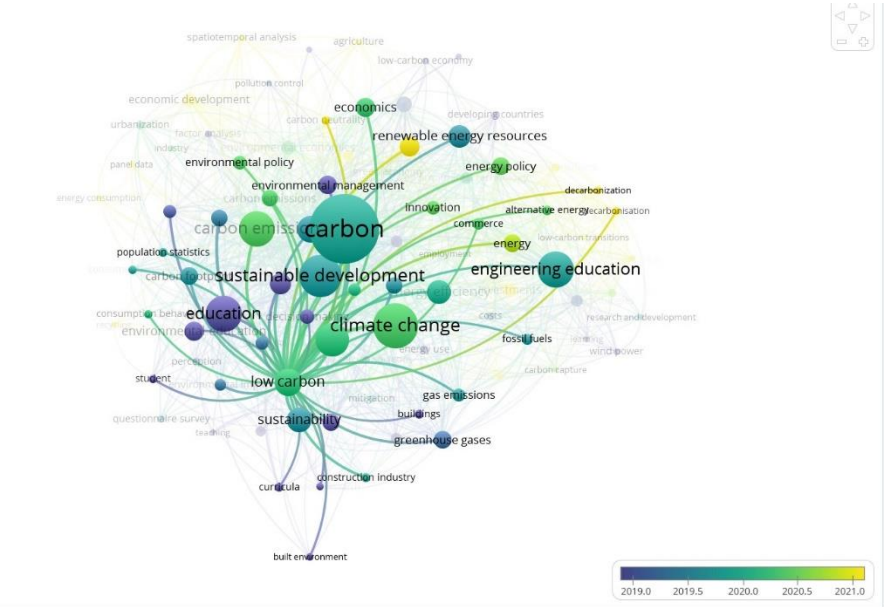

Figure 6. The Overlay of Low Carbon Publication by Recent Year

Conclusion

Based on the results and discussions above, it could be concluded that the development of low carbon education in Indonesia has in the positive improvement. But there are still lack of researcher from Indonesia who make research for low carbon educations. Based on the results of the analysis, there are still many opportunities to research and develop low carbon in the field of education. This opportunity should be utilized properly to achieve the SDGs. The possibility of implementing learning by incorporating low carbon concepts can use various approaches, strategies and models. Engineering Education is something that can be inserted in low carbon learning as well as the results that have been researched. Engineering education is part of STEM education. STEM can be one of the learning approaches in discussing the topic of low carbon. because STEM or PjBL is an approach and learning model based on problem solving with multi-field integration.

Acknowledgment

We would like to thank BPI, Puslapdik, LPDP, the Ministry of Education and Culture, and the Ministry of Finance for funding this research as part of the scholarship funding for doctoral studies.

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