

Shaping a sustainable future: Bibliometric analysis of vocational education curricula aligned with the SDGs

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Abstract: The preparation of SDGs-based vocational education curriculum needs to be prepared. The first step is how this context is discussed globally. This study aims to see how research trends related to vocational education curriculum are in line with the achievement of SDGs. Bibliometric analysis is used to explore information related to these trends. The scope of the research is reviewed based on the year of publication, the most productive countries, documents with the most citations and co-occurrence analysis. This analysis uses the Scopus database as a data source then uses VosViewer to analyze co-citations and co-occurrence. The results obtained were 1041 relevant documents with a period spanning 2015 to February 2024. Based on the year of publication, the topics that examine this theme have significantly increased, then the countries that contribute the most are mostly developed countries such as the United States, England and Spain which are concerned with discussing this theme. Then from the average most citations are in journals published in 2020 which dominate. The co-occurrence results obtained 4 interrelated thematic clusters, namely the relationship between SDGs and education, curriculum, learning models, competencies, technology, educational transformation of the industrial revolution 4.0 and green industry. The implications of this study as a reference for curriculum developers, especially in vocational education which must develop in accordance with the demands of the development of the world of work. This study contributes to increasing insight for researchers who pay attention to themes related to the SDGs-based vocational education curriculum. In addition, it can be used by stakeholders as a reference in preparing the integration of sustainable education in vocational education.

Keywords: Vocational education, Curriculum, SDGs, Bibliometrics analysis

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INTRODUCTION

Creating a sustainable work environment, it is important that individuals have competencies that include knowledge, skills and attitudes that can actively support sustainable development and reduce negative impacts on the environment (Hawkes, 2023) (Field et al., 2023). In this context, the role of vocational education becomes paramount in training a workforce that is not only competent but also able to deal with the changes and complexities of today's industry (Roy & Khastagir, 2016). A sustainability-based curriculum in vocational education requires a comprehensive approach, involving the insertion of sustainability aspects at every stage of learning. This involves the selection of environmentally friendly learning materials, the development of modules that address environmental challenges with innovative solutions,

sustainable infrastructure and the implementation of learning methods that stimulate students' critical thinking and creativity in dealing with environmental issues (Hill & Wang, 2018). In addition, close collaboration with industry and practitioners who have experience in the environment is an important element in ensuring that the curriculum remains relevant to the needs of an increasingly environmentally conscious industrial sector (Brahma & Tripathi, 2020). Thus, vocational education that adopts this approach will play a role in mitigating climate change and preserving the environment for future generations.

Education for Sustainable Development (ESD) has become a major focus in the education sector recently. Strong initiatives have been seen in efforts to integrate ESD concepts into curricula and teaching programs at all levels of education (Gull & Idrees, 2022). Particularly, in the context of vocational education, ESD is emerging as a crucial element in building essential capabilities, such as innovation, lifelong learning, and contribution to human, socio-economic, environmental, and technological development. The UNESCO-UNEVOC International Center plays a central role in promoting ESD, especially in Vocational Education and Training (TVET) (UNESCO-UNEVOC's, 2019). ESD programs are currently relevant to the goals of the Sustainability Development Goals (SDGs) (Report, 2017)(Filho et al., 2018)(Sungkawati, 2024). Of the 17 SDGs, one of them focuses on the field of education listed in point 4, especially SDGs 4.7 (United Nations, 2015). In preparation for sustainable vocational education, it is important to improve human development capacity in accordance with the principles of sustainable systems (Hawkes, 2023)(Field et al., 2023). This includes technical, social, and recognition aspects of sustainable values, which shape learners' mindsets and actions to create a sustainable future (Pradhananga & ElZomor, 2023). Understanding the concept of sustainable development in knowledge, attitude and practice through curriculum, social support and higher education facilities also supports the selection of the most appropriate strategies to achieve sustainability for students (Al-nuaimi, 2022). And the curriculum framework for the preparation of TVET teachers with sustainable literacy should include clear learning outcomes, teaching competencies, sustainable learning approaches, and strategic integration of ESD (Chinedu & Saleem, 2023). With proper preparation, vocational education can be a key driver in achieving the Sustainable Development goals, creating a sustainable future, and producing individuals who contribute to a sustainable society, economy and environment. Therefore, the sustainable education system in vocational education needs to be fully implemented, especially in Indonesia.

The decision to focus this change on vocational education is appropriate, given that current industry demands require a workforce that is competent in their field and also has a positive impact on the environment (Srivastava & Ratilla, 2023). However, before going further in implementing sustainable education in vocational education, it is important to review the extent of research developments that focus on the context of vocational education curricula that are aligned with sustainability systems. Previous research has been done by mapping how the SDGs relate to the curriculum at the University (Adams & Jameel, 2023) then further research related to this context is exploring the relationship between the SDGs and vocational education reveals (Lei & Abidin, 2024). So far, previous research has revealed the relationship between the SDGs but still in the context of the university curriculum, not specifically in the vocational education curriculum. Then further research discusses the SDGs with vocational education but has not fully revealed globally related to vocational education, especially in the context of implementing a curriculum based on sustainability development. Therefore, the main objective of this study is to see an overview of the vocational education curriculum in the SDGs program. This study provides a significant contribution to related parties in the readiness

of vocational education schools to adopt a sustainable education curriculum. In addition, the results of this study are also a valuable study material for future researchers. The details of the research can be formulated:

RQ: 1. How is the development of research in terms of the number of documents per year (2015-2024)?

RQ: 2. How is the development of research in terms of country?

RQ: 3. How does research progress in terms of the most cited documents?

RQ: 4. How is research progressing in terms of co-citation analysis?

METHODS

To analyze the development of research related to vocational education curriculum in alignment with SDGs in preparing sustainable future human resources, we conducted a scientific production analysis and bibliometric mapping from 2015-2024. The analysis was carried out by compiling indicators and also using science mapping to provide a visual representation of topics and their interrelationships in the object of study. Science mapping is a graphical representation of how interrelated fields of knowledge, documents or authors are, exploring the impact of a topic, a group of researchers, or a particular work (Aiolfi & Luceri, 2024). Science mapping also indicates that science mapping analysis is used to show and reveal hidden elements in a particular field. In line with this expression, this research chose the science mapping method because it wanted to identify, analyze and assess the latest developments related to how the vocational education curriculum should be prepared in fulfilling the SDGs program. There are 4 steps in bibliometrics as shown in the figure 1 below (Donthu et al., 2021):

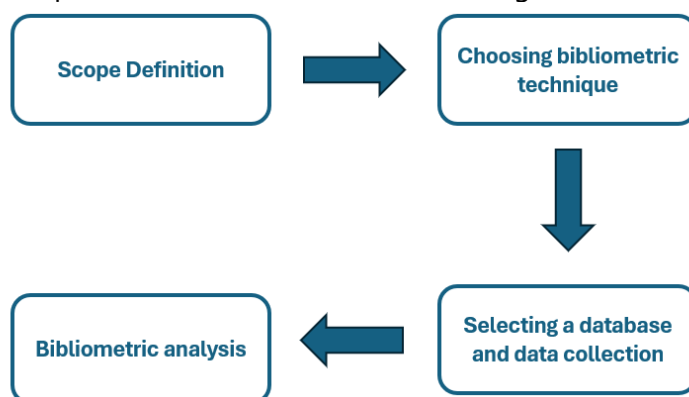


Figure 1. Steps of Bibliometrics

Scope definition

The scope of the research is related to studies related to the vocational education curriculum in the context of SDGs. Relevant topics related to vocational education curriculum and SDGs or sustainability issues. The main focus of the research examines developments based on publication year, country review, then citation and co-occurrence.

Choosing bibliometric techniques

Based on the above scope, several bibliometric techniques were selected such as annual publication growth, country review, citation analysis and cooccurrence. The development of research per year reviews developments that focus on this context to see the enthusiasm of researchers in studying this context (Zhao & Zhou, 2024). Then the country review looks at the distribution of research developments by country (Musango, 2024), citation analysis examines

the number of most citations (Aiolfi & Luceri, 2024). And co-occurrence sees the relationship between keywords (Jain et al., 2023).

Selecting a database and data collection

Scopus was chosen as the source of the data search because it is one of the largest and most credible scientific databases in the world, covering more than 25,000 peer-reviewed journals from various disciplines, including science, engineering, social, and arts. With a rigorous journal selection process, Scopus provides high-quality, globally recognized literature, supporting valid and reliable research. In addition, advanced search features and bibliometric analysis tools, such as h-index and citation analysis, make it easier for researchers to evaluate the relevance and impact of literature. Scopus also excels in supporting interdisciplinary research by providing a global perspective and connectivity between references and related articles (Núñez & Moreno, 2024). The keywords used in the search consisted of major topics related to curriculum, vocational education and the concept of SDGs, as can be seen in Table 1 below. As for data collection, several things are taken into consideration such as the data taken is from 2015 to 2024, then the type of document taken is an article, then the document is finalized, sourced from journals and in English.

Table 1. Keyword Search

No	Keyword	String
1	Curriculum	learning OR crurricula OR curriculum OR "Learning system" OR framework
2	Vocational education	vocational OR tvet OR "vocational education" OR vet OR "vocational school" OR "technical education" OR "engineering education"
3	SDGs issues	green OR sustainab* OR "sustainable development" OR "SDGs" OR "sustainable development goals"
4	Search	TITLE-ABS-KEY green OR sustainab* OR "sustainable development" OR "SDGs" OR "sustainable development goals") AND TITLE-ABS-KEY (learning OR crurricula OR curriculum OR "Learning system" OR framework) AND TITLE-ABS-KEY (vocational OR tvet OR "vocational education" OR vet OR "vocational school" OR "technical education" OR "engineering education")

Bibliometrics analysis

In supporting accuracy, this research uses Vosviewer software which has been widely used in research that has been published in well-known journals with various disciplines (Karyana et al., 2024). Vos viewer provides services for country review, co-citation, and co-occurrence analysis (Eck & Waltman, 2021).

These steps in bibliometric analysis are relevant to the research problem and objectives to pave the way and extract information such as Citation analysis helps identify the most influential articles that inform theory or methodology, while co-citation analysis reveals conceptual relationships between frequently co-referenced studies. Keyword analysis identifies dominant themes and current issues, while network mapping visualizes patterns of collaboration between relevant authors, institutions or themes.

RESULT AND DISCUSSION

The search results in the Scopus database with the above keywords, showed a total of 5,194 documents. After filtering by publication year, document type, source, and language, the number of relevant documents was reduced to 1,041. The following is an interpretation of the research results adjusted to the problem formulation:

Trend research based on publications per year

This study aims to analyze the development of publications per year to measure research productivity in the context of vocational education curriculum that supports the achievement of SDGs. This analysis is important as a first step to understand the current trends before preparing technical preparations. Figure 2 below shows the results of the review of research progress based on the number of annual publications from 2015 to 2024.

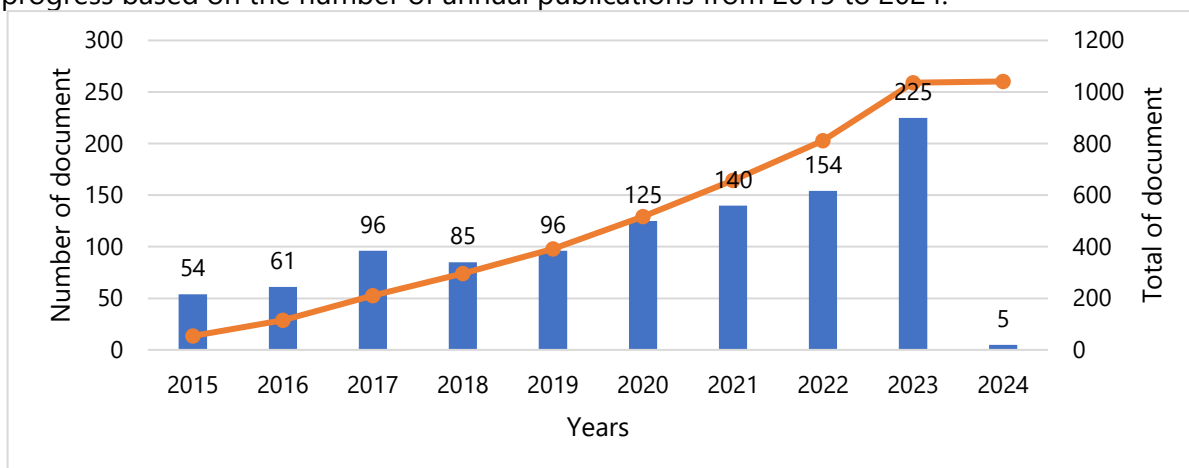


Figure 2. Number of Publications by Year: 2015-February 2024.

Overall, the growth of publications related to vocational education curriculum research in a sustainable era has continued to increase in the last 10 years. The highest number of documents was seen in 2023 and the lowest in 2015. Then in 2024 the review was only until February so the number of documents was still low. This shows that research in the context of vocational education curriculum, especially in terms of alignment with the achievement of SDGs, is a current concern of researchers. This is in line with several study results that emphasize the importance of aligning the vocational education curriculum with the UN SDGs, highlighting that this integration improves teacher expertise and student engagement, fosters critical thinking and ethical awareness, thus contributing to achieving global sustainability goals (Lei & Abidin, 2024).

Trend research country-based research productivity

A review of research progress by country plays an important role in identifying the most research-productive countries, particularly those relevant to this context. The analysis aims to understand the global contribution and distribution patterns of research, as well as identify potential cross-country collaborations. The results of this review highlight the top countries with the highest research productivity that directly relate to the topic at hand. The following illustration in Figure 3 shows the most productive countries.

Figure 3 shows the most productive countries in examining the context of vocational education curriculum aligned with the SDGs. The findings reveal that the five most productive countries in research relevant to this topic are the United States (US), the United Kingdom (UK), Spain, Malaysia and Sweden. The United States took the top spot with the most number of publications, followed by the UK which showed significant contributions. Spain follows with consistent productivity, while Malaysia represents Southeast Asia showing growth in its research contributions. Sweden completes the list with its important role in producing quality research. These findings reflect the different research focuses and capacities in different countries, while opening up opportunities for greater international collaboration. Most of the

top positions are developed countries, which is relevant to the research results that aligning vocational education curricula in developed countries with the Sustainable Development Goals (SDGs) is very important. For example, Norway focuses on collaboration between schools and companies in vocational education and training (Hiim, 2023). Then Southeast Asia representative Malaysia is quite concerned on this issue, focusing specifically on integrating the SDGs into the International School Curriculum to nurture a sustainable society in Malaysia (Wynton & Thomas, 2020)(Chinedu & Saleem, 2023).

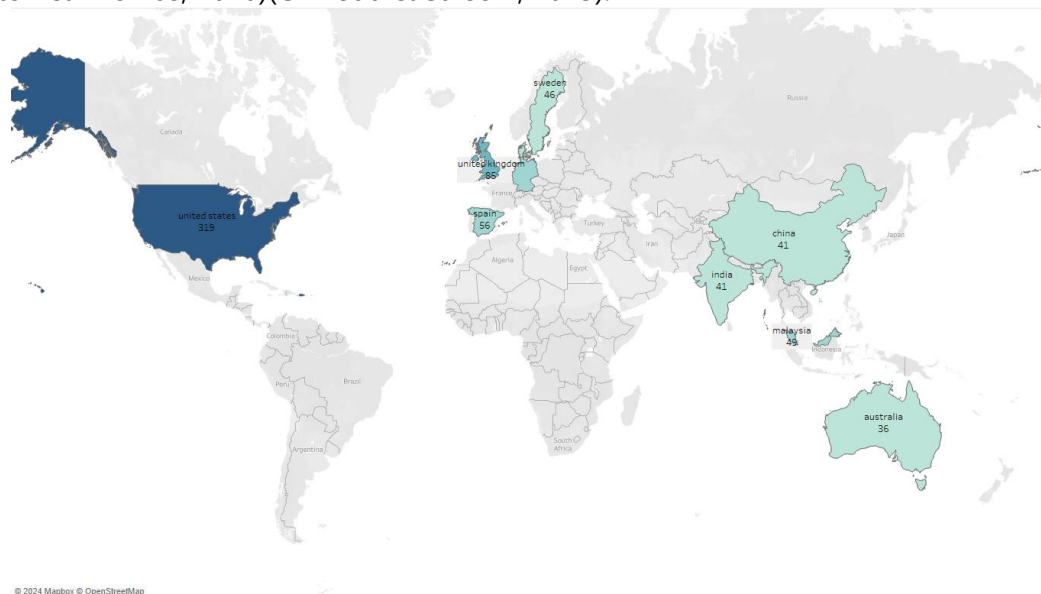


Figure 3. Most Productive Countries

Trend research based on most citations

This review of scientific developments by number of citations is important to see the popularity of the topic or the distribution network of the research. Research with high citations usually indicates that the topic is of widespread interest among scientists or has an effective distribution network. The following presents the results of the research searches with the highest number of citations, as shown in Figure 4.

Figure 4 shows the ten most cited articles published between 2015 and February 2024. This analysis provides valuable insights or information for researchers related to the topic in this context. Such as research (Yadav, G., Kumar, A., Luthra, S., Garza-Reyes, J. A., Kumar, V., & Batista, 2020), is the document with the most citations both in number and in average compared to per year. Then next (Wang & Shao, 2019) and (Tejedor et al., 2018) which are the three most cited in this period. Then in the top ten is occupied by publications ranging from 2016-2020 and dominated by publications in 2020.

Trend research based on topic

Co-occurrence is one of the tools available in VosViewer which is used to analyze the relationship between topics from various documents, especially in the context of the SDGs-based vocational education curriculum. The results are visualized in the form of an interconnected network, with dots of various colors and sizes that show the frequency of occurrence of each topic in the document. The bigger the dot, the more often the topic appears in various documents. Then the color of each dot indicates the scope of the thematic cluster. The following co-occurrence analysis results are shown in Figure 5.

competences, competences science, innovation, life long learning and circular economy, COVID-19 and STEM. This group emphasizes the elements of the relationship between the SDGs and education and learning, then the elements of technology and digitalization and on the issue of sustainability, the content of competencies that are usually characterized in vocational education is also present in this group such as skills, awareness, innovation and life long learning. (2) The green cluster links sustainability systems with fields of expertise such as the 2030 agenda, civil engineering, design education, education for sustainable, electrical engineering, employability, environmental engineering, green skills, pedagogy, service learning, social responsibility, sustainability assessment, sustainability competencies, sustainability in education, sustainability in engineering education, vocational education and training. In this cluster, there is a link between industry 4.0 and educational transformation, both of which go hand in hand to achieve sustainability. (3) The blue cluster is related to learning models, and the Industrial Revolution 4.0. Such as active learning, collaborative learning, design thinking, digitalization, engineering education, green manufacturing, industry 4.0, internet of things, problem based learning, project based learning, social sustainability, sustainable design. This group categorizes related models in vocational education as well as elements of the industrial revolution 4.0 (4) The yellow wana cluster is related to digital technology, education transformation and industry such as artificial intelligence, machine learning, digital transformation, higher education, challenge-based learning, education innovation, environmental sustainability, experiential learning, industrial education and industrial engineering.

The analysis shows that the four thematic clusters found can provide strategic guidance for curriculum development integrated with sustainability goals and the needs of modern vocational education. The red cluster highlights the importance of integrating elements of the SDGs with education and learning through the application of digital technologies, innovation and sustainability competencies such as lifelong learning and circular economy, which are highly relevant to prepare students for global challenges (Garc & Casillas-mart, 2023). The green cluster points to the need to incorporate sustainability competencies in specific areas of expertise such as civil engineering, environmental and vocational engineering, with a focus on transforming education in support of the 2030 Agenda (Barrera, 2022). The blue cluster provides direction for the development of problem- and project-based learning models that integrate Industrial Revolution 4.0 principles, such as design thinking and collaborative learning, which are suitable for supporting active learning in vocational education (Masrifah, 2020). Meanwhile, the yellow cluster emphasizes the importance of adopting digital technologies, such as artificial intelligence and machine learning, in supporting educational transformation and learning innovation, making it relevant for producing graduates who are ready to face the challenges of modern industry (Adenubi & Samuel, 2024). Together, these four clusters offer a conceptual foundation for designing a relevant, innovative and sustainability-oriented curriculum.

CONCLUSION

The research trend related to sustainable-based vocational education curriculum shows a significant increase, especially based on the year of publication which continues to increase. This shows the enthusiasm and concentration of researchers on this theme. Then the country that contributes the most thoughts is dominated by developed countries, where they have stepped and led towards sustainability. In addition, the trend is also shown by several documents with a large number of citations each year. The co-occurrence analysis gives color

to this topic, showing four main clusters. The relationship between sustainability and technology and digitalization, then the transformation of education and the industrial revolution 4.0 that supports sustainability, then the relationship more specifically on the design and learning model with sustainability issues, the relationship of sustainability issues with vocational education and the existence of industrial relationships such as industrial education, engineering and green industry. The benefits of the research can provide global insights related to the sustainable-based vocational education curriculum in preparation for the integration of the SDGs into the vocational education curriculum. However, this research has several limitations such as this analysis is only sourced from the Scopus database, for future researchers it can be added with other databases such as WoS, IEEE and others. Then the bibliometrics analysis has not revealed how this theme globally reviews the field because the identical vocational education has a diverse field of expertise.

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