

# Mapping the Landscape of Sustainability Literacy Research in Vocational Education: A Bibliometric Analysis

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## ABSTRACT

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*Integrating sustainability literacy into vocational education is vital for preparing students to tackle 21st-century sustainability challenges. This study conducts a comprehensive bibliometric analysis to map existing literature on sustainability literacy in vocational education, revealing trends, gaps, and themes. Using the Systematic Literature Network Analysis (SLNA) approach, it combines bibliometrics with systematic literature review (SLR). The customized SLR process identifies relevant Scopus articles from 2018 to 2023 with specific keywords. The analysis identifies eight main topic clusters, including environmental literacy as a key theme. Other clusters cover sustainability literacy, education approaches, vocational training, higher education, and country-specific case studies. The study indicates growing interest in sustainability literacy, seen in the rising publications since 2017. The findings emphasize the need for targeted pedagogical strategies and a more cohesive research landscape to enhance sustainability literacy's impact in vocational education. This research serves two purposes it offers insights into current trends, and inform about the importance of sustainability literacy in vocational education and how it can be implemented. In conclusion, this analysis provides a comprehensive view of sustainability literacy research in vocational education, guiding researchers, policymakers, and educators to improve sustainability education and ready students for sustainability-focused industries.*

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## Introduction

The importance of creating a sustainable future is closely associated with the field of education, which is crucial to enhancing human well-being and ensuring global sustainability. According to research, education plays a pivotal role in determining quality of life and environmental balance

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(Burbules et al., 2020; Décamps et al., 2017). Notably, a recent study that examined the perspectives of postgraduate students in a quantity surveying course revealed that they recognized sustainability knowledge as a driver of employment competitiveness and the importance of sustainability literacy (Opoku & Egbu, 2018). In the context of vocational education, which provides practical skills for specific professions, the integration of sustainable principles becomes crucial. The importance of vocational education as the primary strategy for achieving the 17 Sustainable Development Goals (SDGs) has rendered this necessity even more urgent (Lambini et al., 2021). Vocational education is poised to advance these global objectives by fostering an understanding of sustainable development and its practical implementation (Kabaklarli & Yağmur, 2013). Moreover, vocational education must adapt to the global movement toward sustainability in order to foster students' preparedness for careers in sustainability-focused industries (Kabaklarli & Yağmur, 2013). Furthermore, vocational education ensures that students are aware of and comprehend the SDGs by including them in the curriculum, thereby promoting sustainability literacy in the current workforce (Chen et al., 2022). This literacy then serves as the cornerstone for equipping vocational students with the knowledge they need to take advantage of the opportunities available and overcome the challenges presented by sustainable development (Kuehl et al., 2023).

However, the sustainability literacy research landscape in vocational education unveils its own set of challenges and lacks despite its promising potential. One reason is the absence of a comprehensive understanding of the scope and orientation of research efforts in this field; thus, the formulation of targeted pedagogical strategies to promote sustainability literacy is hampered (Chen et al., 2022). Moreover, the divergence in defining and measuring sustainability literacy across studies results in this lack of clarity being further exacerbated, obscuring its practical integration in vocational curricula. In addition, refining educational approaches and equipping vocational students with the expertise and abilities to meaningfully contribute to sustainable progress are necessary to overcome these challenges.

There is a certain gap in the exploration of cross-disciplinary perspectives and approaches to sustainability literacy in vocational education within this complex system. Nevertheless, a promising perspective emerges from research conducted by Kim & Coonan (2023), which evaluated the potential of cross-disciplinary online courses in encouraging sustainability and human rights awareness in the business environment. Although further in-depth study on the specific relationship between interdisciplinary approaches and sustainability literacy in vocational education is still required, broader research on these topics provides a general direction. In particular, some research emphasized the importance of crossing disciplinary boundaries in sustainable development pedagogical initiatives (Dimenäs & Alexandersson, 2012).

The overall effectiveness and impact of sustainability literacy initiatives in vocational education must be enhanced by bridging these gaps and encouraging a more unified and integrated research landscape. Furthermore, this study has two purposes: first, to conduct a thorough bibliometric analysis of existing literature on sustainability literacy in vocational education, uncovering trends, gaps, and emerging themes; and second, to provide information about the importance of sustainability literacy in vocational education and its implementation. The ultimate purpose was to strengthen the foundation for sustainability education in vocational contexts in order to better prepare future professionals to effectively address 21st-century sustainability challenges.

## **Method**

This study utilized a method called systematic literature network analysis (SLNA). SLNA integrates the systematic literature review (SLR) approach with bibliographic network analysis methods (Ejsmont et al., 2020). The SLNA method was used because it allows an original perspective on sustainability literacy in vocational education and observes the development of the topic over time. Moreover, by applying SLNA, this study was able to define the landscape of scholarly literature on the concept of 'sustainability literacy', and highlight research directions and important areas for development. SLNA began by utilizing bibliometrics, which enables a quantitative assessment of research outputs, including citation analysis, publishing trends, and authorship patterns. This data-driven analysis provided a quantitative basis for next steps. Afterward, the SLR component of SLNA was used to systematically identify and evaluate relevant studies across a large number of scientific databases. SLR ensures a rigorous and unbiased selection process, maximizing literature coverage and minimizing potential bias. The integration of bibliometrics and SLR through SLNA offers a robust and innovative methodology, increasing the validity and reliability of research findings and significantly advancing knowledge in the field under study.

In this study, the systematic literature review (SLR) process was customized based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Protocol (Moher et al., 2009). Additionally, VOSviewer software was utilized for bibliometric analysis. Systematic literature reviews and bibliometric data were collected from several reliable databases, including Scopus, Web of Science (WoS), PubMed, etc. The Scopus database was also used in this search to obtain reliable data for systematic literature reviews and bibliometric analysis. The keywords used for the literature search were "sustain\* literac\*" OR "environmental literac\*" AND "high school\*" OR "universit\*" OR "vocational high school\*" OR "secondary vocational school\*" OR "vocational\*" OR "engineer\*" OR "engineering edu\*" OR "technical edu\*" OR "tvet" OR "vet" OR "career technical education (CTE)". The search was conducted in July 2023.

The exclusion and inclusion criteria for SLR enabled the decision to select documents that were relevant to addressing the research questions. The documents selected were in the form of articles and proceedings, while books and other forms were excluded. After applying the search string to identify the documents, the results were obtained. Moreover, in order to ensure the selected articles complied with the research objectives of the bibliometric analysis of sustainable literacy in vocational education, inclusion and exclusion criteria were established.

Articles that comply with the inclusion criteria had to be published between 2018 and 2023 to reflect the most recent trends, have a vocational education focus, discuss sustainable literacy, or discuss the implementation of teaching strategies that encourage sustainable literacy. Meanwhile, exclusion criteria were used to exclude articles that were out of scope, written in a language other than English, or not published within the specified timeframe. The 2018–2023 period was chosen as it represented the most recent research trends, covered a representative publication cycle, and allowed for actual and relevant analysis without unnecessarily engaging less relevant historical factors. In table 1, the researcher describes the inclusion and exclusion criteria as follows:

Table 1. Article Inclusion and Exclusion Criteria

The inclusion criteria	The exclusion criteria
– The articles are in the realm of vocational education (or other terms);	– The articles are not in the realm of vocational education (like general education or others);
– Articles related to sustainability literacy or discussing implementation of pedagogical strategies that promote sustainability literacy in vocational education;	– Articles unrelated to the inclusion;
– Research articles must be published between 2018 - 2023;	– The research articles are not published between 2018 - 2023;
– The articles use English as the language;	– The article uses a language other than English;

Figure 1 displays the results of the co-occurrence analysis of the research topics found in the literature on sustainability literacy in vocational education. Co-occurrence analysis used VOSviewer software to identify keywords that often co-occurred in the abstracts and titles of articles. Then, clusters or topic groups were formed from keywords that have a tendency to co-occur. For example, the keywords “environmental literacy”, “education for sustainable development”, and other related



technical education. Meanwhile, the yellow cluster was related to higher education. This shows concern for the role of tertiary institutions in developing sustainability literacy among students. Additionally, the orange cluster focused on case studies in China. It was obvious that Chinese literature has made a considerable contribution to this topic. In light of this, it can be concluded that in addition to environmental literacy, research on sustainability literacy also pays great attention to topics such as sustainability education, pedagogical approaches, vocational and technical education, higher education, as well as case studies in certain countries such as China.

**Distribution of Articles by Year of Publication**

As demonstrated in Figure 2, the community of education and sustainable research has given the topic of sustainability literacy more importance and attention, which is evident from the increasing number of publications since that year. This trend is supported by various research articles that emphasized the pivotal role of sustainability literacy in influencing the development of a sustainable future. In particular, Burbules et al (2020) study emphasized the critical role of education and technology, including sustainability literacy, in realizing a sustainable future. Furthermore, research by Opoku & Egbu (2018) evaluated students’ perspectives on the relevance of sustainability literacy to their future employability, highlighting how sustainability literacy was recognized by students as a driver for employment competitiveness. The relevance of vocational education and training for sustainable development was also examined by Kabaklarli & Yağmur (2013) study, further demonstrating the crucial role that education plays in sustainability. Additionally, Kuehl et al (2023) explained sustainability literacy as a fundamental element that equipped students with the skills needed to deal with sustainable challenges and opportunities. These collective research efforts reinforce the increasing attention and importance accorded to sustainability literacy in the fields of education and sustainable development. In other words, several studies have explicitly demonstrated that sustainability literacy is crucial in determining the readiness of the younger generation to contribute to sustainable development in the future.

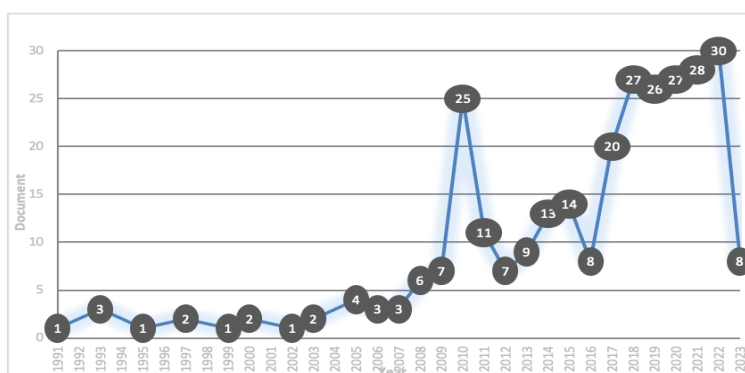


Fig 2: Documents distribution by year of publication

### Article Distribution by Country

Based on the distribution of published articles by the continent of the authors, several conclusions could be drawn. Firstly, the American continent had the highest number of publications, indicating that this continent was very interested in conducting state mapping research. Secondly, Europe ranked second in terms of providing a significant contribution to the advancement of knowledge in this field. Thirdly, Asia was in third place, demonstrating the commitment of the Asian region, particularly developing nations, to state mapping research. Fourthly, Oceania and Africa had fewer published articles, suggesting low research interest in these two continents. In comparison to the Eastern Hemisphere, the Western Hemisphere's continents, especially the Americas, dominated the majority of the publishing world. According to this study, there was an increase in journals containing research on sustainability curriculum in higher education. The majority of cases were from the USA, Europe, and Asia, with the highest concentration in Oceania. Moreover, Western countries exchanged information openly, but there was limited interaction between them and other countries, indicating limited cross-country learning. This was also supported by the research of Weiss and Barth (2019), which discovered there was an increase in the publication of research on sustainability curriculum in higher education journals, most of which came from the United States, Europe, and Asia, with a significant number from Oceania. The data presented in Figure 3 represents the number of articles published on various continents.



Fig 3: Article Distribution by Continent

The distribution of research on sustainability literacy across the top ten countries with the highest publication rates reflects diverse interests and commitments to this issue. The United States led in the first position with the highest number of publications, indicating a strong dedication and interest in conducting research on sustainability issues and sustainable development. Meanwhile, in second place was Indonesia, which also actively engaged in producing research and publications

in the field of sustainability literacy, demonstrating its involvement and concern for the issue. Both developed countries like the United States and developing nations like Indonesia seem to share a similar commitment to supporting sustainable development through research in this field.

China, which was ranked third, provided evidence that developing countries also prioritize sustainability concerns by focusing on relevant research. The distribution of these publications serves as further evidence that sustainability concerns and sustainable development have become global concerns, involving countries with diverse economic and social backgrounds. By examining the distribution of publications by country, it could be concluded that the growing interest in sustainability literacy is a crucial step toward global awareness and improved actions in preserving and maintaining the environment for a sustainable future. This was supported by Leiva-Brondo et al. (2022), who emphasized the importance of assessing students' sustainability knowledge, skills, and attitudes both at the beginning and end of their programs. This examination assisted in determining the effectiveness of educational strategies and identifying areas that need improvement. In addition, Figure 4 displays the top 10 countries with the highest publication rates.

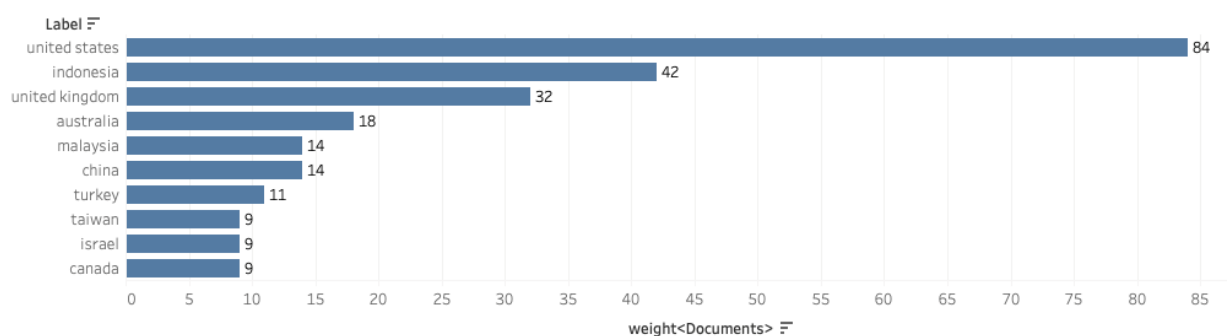


Fig 4: Documents distribution by country of publication

Several studies have investigated the causes that contribute to this inequality, including lower higher education participation, scientific 'brain drain', lower per capita research expenditure, weaker institutional support, and fewer funding opportunities (Minasny et al., 2020). Additionally, there must be a more balanced representation of North and South in sustainability research to define global sustainability challenges, our relationship to them, and the way we think about studying them and developing global environmental policy (Dangles et al., 2022).

#### Article Distribution by Source

Table 2 provides information about the distribution of articles on sustainability literacy in vocational education based on their sources. The table lists the titles of the journals where these articles were published, along with the number of articles associated with each journal. This analysis allowed us to gain insights into the scientific landscape and pinpoint the most important directions



for future research in this field. Moreover, the study's inclusion of a wide range of journals highlighted the interdisciplinary nature of sustainability literacy research in vocational education. The inclusion of diverse journals ensured that research findings would reach a broader audience and contribute to various disciplines.

After analyzing Table 2, several prominent journals became apparent in terms of the number of articles published on sustainability literacy in vocational education. These journals serve as an essential means for researchers to share their insights and findings in this area. One of the most prominent journals was the "Journal of Vocational Education and Training," which seems to be the main means for research on vocational education. Compared to other articles in this field, this study placed a major emphasis on the intersection of sustainability and vocational education. Moreover, the articles that have been included in this study suggest that researchers recognize the importance of incorporating sustainability principles into vocational curricula and pedagogical practices. For more details, see Table 2.

Table 2. Top 5 Article Source

<i>Source</i>	<i>Documents</i>	<i>Citations</i>
International journal of sustainability in higher education	21	297
Journal of physics : conference series	19	25
Sustainability (switzerland)	17	137
Teaching environmental literacy: across campus and across the curriculum	16	32
Environmental education research	12	284

In general, Table 2 reflects a diverse range of journals that have published articles on sustainability literacy in vocational education. The fact that articles about sustainability were published in these journals demonstrated the growing interest in and recognition of sustainability as a crucial component of vocational education. It also highlighted the interdisciplinary nature of sustainability literacy research, with contributions from fields such as vocational education, higher education, sustainability studies, environmental education, and teacher education. The distribution of articles across various journals emphasized the significance of distributing research findings to a wider audience, fostering collaboration, and promoting the integration of sustainability principles into vocational education practices. I

n addition, as this study contains articles published in various journals, it was expected that this study will serve as a resource that researchers and educators can use to gain insights, develop evidence-based pedagogical strategies, and address the complex sustainability challenges of the 21st century in vocational education settings. The journal with the most documents related to

sustainability literacy is International Journal of Sustainability in Higher Education. This journal focuses specifically on sustainability in higher education, making it a suitable outlet for research related to vocational education. It covers a wide range of topics, including curriculum development, pedagogy, and institutional practices. Researchers may choose this journal because it provides a platform to reach a broad audience of educators, administrators, and policymakers interested in sustainability in higher education.

The second journal is Journal of physics : conference series. While this journal primarily focuses on physics, it may be selected for publishing research on sustainability literacy in vocational education if the studies have a strong emphasis on physics education or the application of physics principles to sustainability. This journal is known for publishing conference proceedings and has published extensively on topics concerning vocational education. Sustainability (Switzerland) as a leading journal in the field of sustainability, this outlet attracts a wide range of interdisciplinary research related to sustainable development. It covers topics such as environmental science, policy, education, and social aspects of sustainability. Researchers may choose this journal because it offers a platform to reach a diverse audience interested in sustainability issues, including vocational education and learning.

**Systematic Literature Review Analysis**

Table 3. Article Overview

<i>Article</i>	<i>Author</i>	<i>Title</i>	<i>Year</i>	<i>Source</i>
A1	Chinedu et al	Teaching and Learning Approaches: Curriculum Framework for Sustainability Literacy for Technical and Vocational Teacher Training Programmes in Malaysia	2023	Sustainability (Switzerland)
A2	Ma & Jin	Increasing Sustainability Literacy for Environmental Design Students: A Transdisciplinary Learning Practice	2022	Sustainability (Switzerland)
A3	Akeel et al	Assessing the sustainability literacy of the Nigerian engineering community	2019	Journal of Cleaner Production
A4	Isakovic,	Innovation and entrepreneurship courses for engineering students in the MENA region for enhancement of sustainability literacy	2014	Proceedings of 2014 International Conference on Interactive Collaborative Learning, ICL 2014
A5	Lamere et al	Mapping and Enhancing Sustainability Literacy and Competencies within an Undergraduate Engineering Curriculum	2021	9th Research in Engineering Education Symposium and 32nd Australasian Association for Engineering Education Conference, REES AAEE 2021: Engineering Education Research Capability Development

After all papers had been extensively searched and specific inclusion and exclusion criteria had been applied, a total of five papers that complied with the specified criteria were selected. Additionally, these selected items and brief descriptions were provided in Table 3 as a comprehensive overview.

The results of this review were summarized in order to highlight important findings relevant to the discussion of various implementations and benefits of sustainability literacy in vocational or engineering education. In addition, these major findings were summarized to provide a clear and comprehensive understanding of the issue.

Vocational education plays a vital role in achieving the 17 Sustainable Development Goals (SDGs). Moreover, vocational education ensures that students acknowledge and comprehend the SDGs' goals by integrating the SDGs into the curriculum, thereby improving the sustainability literacy of the workforce. Furthermore, by highlighting areas where sustainability capabilities may be integrated into professional contexts, the findings allow professionals to make a significant contribution to sustainable advancement.

Table 4. Significant findings

<i>Article</i>	<i>implementation</i>	<i>Benefit</i>
A1	The framework includes four important curricular elements: learning outcomes for sustainability literacy, teaching competencies for sustainability literacy, pedagogical approaches for effective teaching and learning, and strategies for integrating education for sustainable development (ESD). The pedagogical strategies aim to foster sustainability literacy among vocational teachers and students, enabling them to make environmentally friendly, socially acceptable, and economically viable decisions. The framework provides a guide for designing and implementing pedagogical strategies that promote sustainability literacy in vocational education.	Sustainability literacy is crucial in vocational education as it equips individuals with the knowledge, skills, and understanding to make environmentally friendly decisions and promote social well-being. It enables vocational educators to educate for sustainable development and contribute to sustainable economies. By integrating sustainability principles into the curriculum, vocational education can play a vital role in developing sustainability-literate teachers and workers who can address the environmental, social, and economic challenges of our world.
A2	This approach implemented at NingboTech University integrates environmental engineering concepts into landscape design education to promote sustainability literacy. Strategies include merging disciplines, utilizing diverse teaching methods, fostering outdoor learning, engaging in project-based collaboration, and evaluating outcomes. This approach enhances students' commitment to sustainable design while identifying areas for refinement, providing valuable insights for similar educational initiatives.	Vocational fields impact sustainability directly, necessitating awareness. Integrating sustainability enhances holistic thinking, values, and skills, vital for solutions and real-world issues. This aligns education with pressing concerns and interdisciplinary collaboration. Article evidence reinforces sustainability literacy's role in preparing students for impactful careers amid urgent socio-environmental problems.

<i>Article</i>	<i>implementation</i>	<i>Benefit</i>
A3	The article emphasizes the importance of improving sustainability literacy through education interventions, particularly for the Nigerian engineering community which was found to have low literacy levels. This suggests vocational education programs would benefit from sustainability education.	A study on Nigerian engineering students, educators, and practitioners revealed significant deficiencies, highlighting the need for improved sustainability education. To address this, the article suggests integrating sustainability courses into the curriculum, focusing on sustainable engineering principles, systems thinking, and local context application. This is crucial for equipping graduates to tackle regional and global sustainability challenges effectively. In essence, sustainability literacy empowers vocational participants, shaping their ability to implement sustainable practices and contribute meaningfully to their fields.
A4	This pedagogical approach focuses on preparing engineering students for sustainability challenges through the "Innovation and Entrepreneurship" course, fostering multidisciplinary collaboration and critical thinking. It measures sustainability literacy gain, bridging conceptual gaps, and represents a pivotal step in curriculum reform, emphasizing the integration of sustainability in vocational education while providing practical implementation insights.	The article emphasizes the need for vocational students to possess a quantifiable level of sustainability literacy, particularly in regions like the United Arab Emirates and the MENA region. With ongoing curricular reforms and a focus on training engineers with sustainability literacy, vocational education plays a vital role in preparing the next generation of graduates who can effectively address sustainability challenges.
A5	Curriculum mapping and coordination across course modules to ensure integration and streamlining of sustainability content. The article also mentions the importance of leadership and support from management, such as faculty deans and heads of department, in implementing sustainability education. Additionally, the article highlights the need for a student-centered, interdisciplinary, and team-teaching approach to expose students to multiple perspectives on sustainability-related issues. Overall, the article emphasizes the importance of incorporating sustainability education into vocational curricula through a phased and programmatic approach.	Engineers are expected to deliver technological solutions that maximize social value while minimizing environmental impact. By integrating sustainability into the curriculum, vocational education institutions can ensure that graduates are prepared to work and live in ways that safeguard environmental, social, and economic well-being. This helps create a workforce that can contribute to a sustainable global society and knowledge economy.

Additionally, this study explored the implementation of various pedagogical strategies to enhance sustainability literacy in technical and vocational education programs. The main goal was to equip vocational students, particularly those in engineering and related fields, with the knowledge, skills, and perspectives needed to address the complex sustainability challenges facing our world today.

### **1. Curriculum Framework for Sustainability Literacy**

The first article by Chinedu et al. (2023) introduced a comprehensive curriculum framework for sustainability literacy in technical and vocational teacher training programs. This framework

comprised four essential components: learning outcomes for sustainability literacy, teaching competencies for sustainability literacy, effective pedagogical approaches, and strategies for integrating education for sustainable development (ESD). Moreover, vocational education is poised to play a pivotal role in generating teachers and workers who are sustainability-literate and capable of making environmentally friendly, socially responsible, and economically viable decisions by integrating sustainability principles into the curriculum. This framework serves as a guide for designing and implementing pedagogical strategies that promote sustainability literacy in vocational education. In addition, technical and vocational teachers who were in charge of worker training lack the competencies necessary to engage in sustainability education (Chinedu et al., 2023).

According to Hale et al. (2015), there are four essential ways of thinking—futures, values, systems, and strategic thinking—that are interrelated and bidirectional. The framework's focus was to develop a sustainable approach that is problem-oriented and solution-based, equipping educators with the skills, knowledge, and attitudes needed to address complex challenges. It highlighted the interrelated nature of diverse sustainability topics, enabling teachers to comprehend their relevance and relationship to both the classroom and society. Moreover, this framework allowed for in-depth comprehension of sustainability in real-world contexts by encouraging self-reflection and independent research. The organizational principles in this article provided for a coherent examination of sustainability challenges and solutions, as well as a structured approach for interpersonal, intragroup, and intergroup scenarios. Additionally, it encouraged the investigation and identification of methods toward a sustainable future by fostering critical research into societal values, equity, and future goals. In summary, these components collectively equipped educators with the knowledge and perspectives necessary to promote sustainability literacy and effectively address sustainability issues. Furthermore, by incorporating these components into sustainability education, educators may effectively address sustainability issues and equip students to take an active role in creating change for a sustainable future.

## **2. *Integrating Environmental Engineering and Landscape Design***

The second article by Ma and Jin (2022) presented an innovative approach implemented at Ningbo University of Technology, in which environmental engineering concepts were merged into landscape design education to enhance sustainability literacy. The strategies employed included interdisciplinary collaboration, diverse teaching methods, outdoor learning experiences, project-based learning, and outcome assessment. By integrating sustainability principles into vocational education, students were better prepared to comprehend and address complex issues such as climate change and resource management. This approach emphasized the importance of holistic

thinking, values, and skills necessary for addressing real-world sustainability challenges. Moreover, the approach adopted was consistent with the wider context of sustainability education by promoting interdisciplinary collaboration, using diverse teaching methods, integrating sustainability principles, promoting holistic thinking and values, and developing skills to address sustainability challenges. Furthermore, the slow advancement of sustainability integration in built environment curricula may be partially due to the practice-led approach, which is a hallmark of the discipline (Iyer-Raniga & Andamon, 2012). By implementing such strategies, educational institutions may improve sustainability literacy and prepare students to make meaningful contributions to sustainability efforts in their fields.

### **3. *Education Interventions for Nigerian Engineering Community***

The third article by Akeel et al. (2019) emphasized the significance of education interventions to improve sustainability literacy within the Nigerian engineering community, which has been identified as having low literacy levels. This highlighted the critical need for sustainability education in vocational programs. The article suggested integrating sustainability courses into the curriculum, focusing on sustainable engineering principles, systems thinking, and local context application. One of the methods to achieve this was by implementing sustainability pedagogy. Sustainability pedagogy is a tool for creating transformational sustainability learning that is thematic and co-created, critically questions dominant norms and incorporates diverse perspectives, is active, participatory and relational, and is grounded in a specific place (Burns, 2015). By applying sustainable engineering principles, such as life cycle assessment, eco-design, and renewable energy, students gain a comprehensive understanding of how engineering may contribute to sustainable development. This was in line with the broader context of sustainability education, which recognizes the role of engineering in the development of sustainable solutions.

### **4. *Innovation and Entrepreneurship for Sustainability Challenges***

The fourth article by Isakovic (2014) detailed a pedagogical approach for preparing engineering students for sustainability challenges that centered on the “Innovation and Entrepreneurship” course. This approach fostered interdisciplinary collaboration, critical thinking, and sustainability literacy while bridging conceptual gaps. The article emphasized the importance of vocational students possessing quantifiable levels of sustainability literacy, particularly in regions like the United Arab Emirates and the MENA region. In addition, curriculum reform in vocational education, with a focus on sustainability integration, is pivotal to producing graduates capable of effectively addressing sustainability challenges.

### **5. Phased Approach to Incorporating Sustainability Education**

The fifth article highlighted various pedagogical strategies for promoting sustainability literacy in vocational education. These strategies encompassed curriculum mapping, interdisciplinary approaches, team teaching, and leadership support from management. The article emphasized the importance of exposing students to multiple perspectives on sustainability-related issues. By incorporating sustainability education through a phased and programmatic approach, vocational education institutions may generate graduates who are adept at delivering technological solutions while safeguarding environmental, social, and economic well-being. Based on Moosavi and Bush (2021), who evaluated an interdisciplinary studio at the University of Melbourne, certain teaching methods were proposed to enhance sustainability literacy through studio teaching. These methods emphasized the importance of sustainable development goals in urban contexts by simulating real-world sustainability challenges. Moreover, the encouragement of collaborative learning focused on integrated group assessments that emphasized all aspects of sustainability. Furthermore, a further way to encourage reflection-in-action and relevance is to take part in community of practice activities like stakeholder workshops and external jury panels. In addition, another way is to incorporate game-based activities and role-play that encourage teamwork, negotiation, creativity, and self-motivation among students.

### **Conclusion**

In conclusion, this bibliometric analysis provides important insights into research on sustainability literacy in vocational education. The research revealed environmental literacy and sustainability literacy as the two main topics, highlighting the importance of these issues. Moreover, publications have increased in recent years, indicating a growing recognition for integrating sustainability principles into vocational education and generating graduates who are prepared for employment. However, research gaps were identified, including a lack of comprehensive understanding and different definitions of sustainability literacy. In addition, these findings suggested the need for focused techniques and coherent research goals.

This study has practical implications for the development of policies and curricula. Moreover, insights into trends and themes may guide the development of evidence-based pedagogical methods. Furthermore, understanding challenges and gaps also supports improved measurement and alignment of sustainability literacy frameworks. Overall, this comprehensive landscape mapping demonstrated the importance of sustainability literacy for vocational learning. Additionally, changes in curriculum that equip students with relevant knowledge and skills will foster a workforce that is prepared to face the complex sustainability challenges of the future. In addition, these findings provide valuable guidance to achieve the ultimate goal of developing

industry professionals who are ready to promote sustainable advancement. It was also suggested that vocational curricula give priority to and integrate environmental and sustainability literacy as key themes. This may result in the development of new courses or the inclusion of these concepts in subject standards. Besides, addressing challenges like the lack of comprehensive understanding highlighted the importance of mapping learning outcomes across qualifications and programs to align curricula with industry needs.

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