Proceeding International Conference on Religion, Science and Education (2025) **4**, 335-347

Sustainability Literacy in Higher Education: A Bibliometric Overview

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Abstract: Sustainability literacy is an competence that must be developed in sustainable education. This study aims to examine research trends on sustainability literacy in higher education through bibliometric analysis. The research uses the Scopus database with the keywords "Sustainability Consciousness" or "Sustainability Awareness" or "Sustainability Literacy" or "Sustainable Literacy" and "Higher Education" for the years 2015-2024. A total of 136 documents were retrieved, and after filtering for English language, journal publications, final publications, and open access, 44 documents were selected. Biblioshiny and VOSViewer programs were used for bibliometric analysis. The results show that the last two years (2022) had the highest number of studies on this theme. It was revealed that the United States is the most country in producing research in this area, followed by the UK, Saudi Arabia, Spain, and Australia. Sustainability (Switzerland) was identified as the journal that published the most articles on the topic and is the most cited. The most frequently used terms in these articles were "sustainability", "higher education", "student", "sustainable development", and "university". The results of research analysis indicate that there is a variation in evaluation tools used by researchers worldwide to measure sustainable literacy. However, in general, researchers around the world use questionnaires and tests to assess sustainable literacy. On the other hand, the analysis also reveals that integrating sustainable literacy into higher education curricula is a crucial effort in achieving sustainable development.

Keywords: bibliometric, higher education, sustainable development, sustainability literacy.

Introduction

Sustainable literacy is an important skill as an effort to achieve sustainable development (Ozdemir, 2023; Vilmala et al., 2022). Sustainable development, outlined in the United Nations 2030 Sustainable Development Agenda, consists of 17 Sustainable Development Goals (SDGs) and represents a significant effort to address the complex global challenges of our time. These challenges include ecosystem degradation, species extinction, depletion and degradation of vital resources, various forms of pollution, and widespread extreme poverty affecting millions of people. These global challenges are believed to stem from a lack of individual or community awareness in caring for the Earth. Therefore, introducing sustainable literacy through continuous education is essential.

Sustainable literacy is understood as the knowledge, skills, and mindset that enable individuals to be highly committed to building a sustainable future and to assist one another in making appropriate and effective decisions toward a sustainable society (M. Mason & Sulitest, 2019). Sustainable literacy has become a key outcome in sustainable education, representing a transitional competency toward a sustainable society (Leiva-Brondo et al., 2022; Winter & Cotton, 2012). Individuals with sustainable literacy are able to understand the symbiotic relationship between the environmental, social, and economic dimensions of sustainable development. They can integrate relevant knowledge with skills and, furthermore,

ISSN 2829-3355| EISSN 2828-8467

recognize and appreciate the sustainable actions taken by others (Ozdemir, 2023).

Many studies have examined sustainable literacy as a form of environmental awareness. For instance, research by Putri et al. found that students' sustainable literacy, particularly regarding perceptions of environmental change, remains low. Thus, they recommend the importance of introducing sustainable literacy related to environmental issues at the higher education level. Teaching and learning about sustainable literacy actively is seen as a potential solution to improving sustainable literacy (Putri et al., 2023). Adam et al. analyzed science education in relation to students' sustainable literacy. Through experimental methods, they observed that improvements in sustainable literacy within science education remain in the low category, especially concerning environmental aspects, which are also categorized as low (Adam et al., 2021). However, there has been limited in-depth research on sustainable literacy at the higher education level. Higher education institutions should support sustainable development and have a responsibility to teach sustainable literacy, ultimately producing environmentally conscious citizens. Sustainable education is especially important at the university level, as students will soon pursue careers across various professions and need to understand the impact of their professions in addressing sustainability challenges.

The importance of sustainable literacy has led to an increase in literature examining this topic. As research on sustainable literacy grows, rigorous and comprehensive review becomes an urgent need. Bibliometric analysis serves as a highly valuable tool in this regard. The primary goals of bibliometrics are to facilitate the examination of publication pathways, identify influential authors and institutions, map research clusters, and track emerging trends within the field of sustainable literacy (Solih et al., 2024). Bibliometric analysis offers advantages, particularly objectivity and quantification, which help to avoid subjective bias (Linnenluecke et al., 2020). Furthermore, bibliometric studies rely on reliable citation data from databases such as WoS and Scopus (Baako & Abroampa, 2023). Scientists have noted that bibliometric techniques provide an interdisciplinary approach to effectively mapping topics and themes in research fields (Khanra et al., 2020, 2021; Liao et al., 2018).

Based on the above explanation, this study aims to analyze research trends in sustainable literacy at the higher education level from 2015 to 2024 and visualize them through bibliometric analysis. By focusing on the period of 2015-2024, this review seeks to highlight recent developments in the field and provide an updated analysis of the research landscape.

Research Questions

This research focuses on trends in sustainable literacy research at the higher education level from 2015 to 2024, with four research questions:

a. What is the profile of publication output for sustainable literacy research at the higher education level from 2015 to 2024?
b. What is the distribution of sustainable literacy research publications at the higher education level from 2015 to 2024 across countries and affiliations worldwide?
c. Who are the most productive authors in sustainable literacy research at the higher education level worldwide from 2015 to 2024?
d. What is the visualization of the trends in research on sustainable literacy research trends at the higher education level from 2015 to 2024 be visualized?
e. What are the evaluation tools used in measuring sustainable literacy??

Materials and Methods

Research Tools

This study uses the assistance of Publish or Perish (PoP) software, Bibliometrix with R programming (biblioshiny), and VOSviewer. Publish or Perish can be used to compare a set of specific journals based on certain characteristics or to test hypotheses on topics such as research collaboration (https://harzing.com/). Publish or Perish is used to conduct a literature review on the selected theme, thus creating a database of related research themes. It helps identify the most cited authors, the oldest

and latest articles, and provides bibliometric records for each study used. Publish or Perish offers several data source options, such as Scopus, Crossref, Google Scholar, Google Scholar Profile, PubMed, Microsoft Academic, Scopus, and Web of Science (Al Husaeni & Nandiyanto, 2021). Biblioshiny is an open-source application capable of importing data from various sources (Scopus, Web of Science, etc.) and providing various types of bibliometric analysis (Mishra et al., 2023). In this study, we utilized several modules offered by the Bibliometrix application, including key information, annual scientific production, citations, relevant sources, authors and affiliations, countries, and a word cloud. VOSviewer, another widely used bibliometric tool, creates bibliometric networks (e.g., authors and organizations) using various network analysis methods such as co-authorship, co-citation, co-occurrence of terms, and bibliographic coupling (Mishra et al., 2023). VOSviewer presents and represents specific information about bibliometric graphical maps (Baier-Fuentes et al., 2019). In this study, we used co-occurrence analysis of terms to identify key themes within the research domain.

Data Collection

The literature data collection uses the Scopus database. Scopus is considered a high-quality data source, making it a key choice for document selection (Wei et al., 2023). Data selection was conducted using the PRISMA method, which is one of the most widely used methods for systematic literature reviews (Page et al., 2021). The PRISMA method provides a roadmap for reporting systematic reviews in a transparent, objective, and explicit manner (Rehman et al., 2020). This systematic review employs bibliometrics (see Figure 1) adapted from Kulakli & Osmanaj, Yang et al., Bonilla-Chaves & Palos-Sánchez, and Wei et al. (Bonilla-Chaves & Palos-Sánchez, 2023; Kulakli & Osmanaj, 2020; Wei et al., 2023; Yang et al., 2017).

Data Analysis

The literature search was conducted in September-October 2024 using the Publish or Perish (PoP) application. This study used the keywords "Sustainability Consciousness" or "Sustainability Awareness" or "Sustainability Literacy" or "Sustainable Literacy" and "Higher Education" for the years 2015-2024. A total of 136 documents were retrieved, and after filtering for English language, journal publications, final publications, and open access, 119 documents were selected. The documents obtained were then analyzed for relevance to the topic, resulting in a final dataset of 44 documents. Bibliometric analysis was conducted using Biblioshiny and VOSViewer programs, with data documented in (.csv) format. This data was then processed and analyzed using VOSViewer and Biblioshiny to analyze research trends in sustainable literacy in higher education.

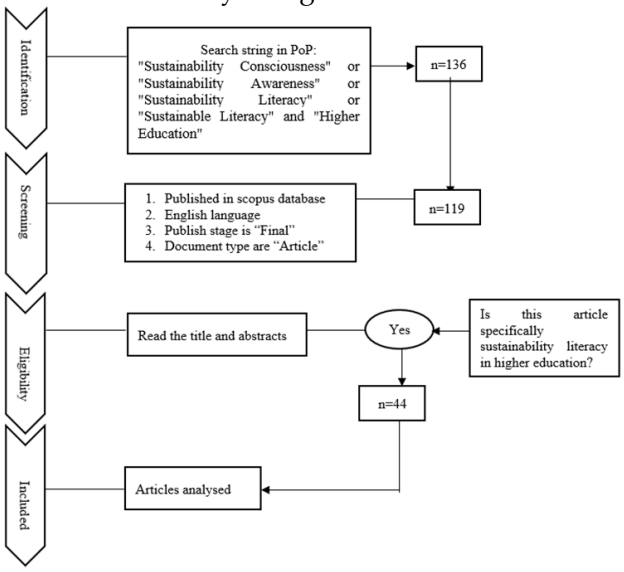

Figure 1. Steps for Document Search for Bibliometric Analysis

Results and Discussion

Profile of Publication Output on Sustainable Literacy Research in Higher Education from 2015-2024

The search for relevant scholarly articles on sustainable literacy research in higher education in the Scopus database yielded 44 documents. The publications analyzed from 2015 to 2024, shown in Figure 2, indicate that research on sustainable literacy in higher education began to gain significance in 2019, with a significant increase in 2022 (see Figure 2). The rise in the number of articles published in Scopus-indexed journals suggests that this research topic is relatively new and is being studied with a more scientific

approach. On the other hand, this increase is also due to the fact that this topic has become a global initiative, leading to more international cases being documented.

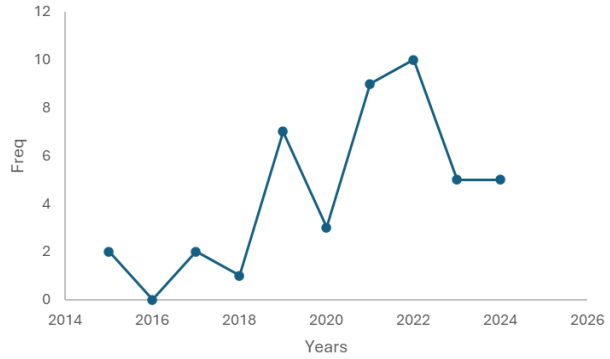

Figure 2. Number of Sustainable Literacy Research Documents at the Higher Education

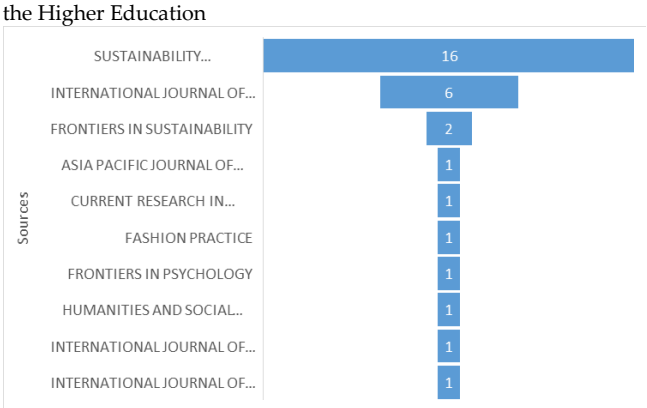

Figure 3. Distribution of Sustainable Literacy Publications at the Higher Education by Source

Figure 3 shows that the most published research on sustainable literacy at the higher education level is in the journal SUSTAINABILITY, with 16 publications. The next most published journal is the INTERNATIONAL JOURNAL OF SUSTAINABILITY IN HIGHER EDUCATION with 6 documents. Based on the number of citations from publications conducted by researchers worldwide, the following are the 10 most-cited publications.

Table 1. The Most Citation Count from the 10 Publications

Author	Years	Title	Journal	Total Citations
MALIK MN (Malik et al., 2019)	2019	Investigating Students' Sustainability Awareness and the Curriculum of Technology Education in Pakistan	SUSTAINABILITY	48
ALKHAYYAL B (Alkhayyal et al., 2019)	2019	Analyzing Sustainability Awareness among Higher Education Faculty Members: A Case Study in Saudi Arabia	SUSTAINABILITY	38
LEIVA-BRONDO M (Leiva-Brondo et al., 2022)	2022	Spanish University Students' Awareness and Perception of Sustainable Development Goals and Sustainability Literacy	SUSTAINABILITY	34
MARCOS-MERINO JM (Marco Perles & Esteve Martín, 2017)	2020	Analysis of Sustainability Knowingness, Attitudes and Behavior of a Spanish Pre-Service Primary Teachers Sample	SUSTAINABILITY	30
WINFIELD F (Winfield & Ndlovu, 2019)	2019	"Future-proof your Degree": Embedding sustainability and employability at Nottingham Business School	INT J SUSTAIN HIGH EDUC	22
PFAUTSCH S (Pfautsch & Gray, 2017)	2017	Low factual understanding and high anxiety about climate warming impedes university students to become sustainability stewards: An Australian case study	INT J SUSTAIN HIGH EDUC	22
AKEEL U (Akeel et al., 2019)	2019	Assessing the sustainability literacy of the Nigerian engineering community	J CLEAN PROD	21
ASHRAF MW (Ashraf & Alanezi, 2020)	2020	Incorporation of Sustainability Concepts into the Engineering Core Program by Adopting a Micro Curriculum Approach: A Case Study in Saudi Arabia	SUSTAINABILITY	20
HSU JL (Hsu & Pivec, 2021)	2021	Integration of Sustainability Awareness in Entrepreneurship Education	SUSTAINABILITY	20

Author	Years	Title	Journal	Total Citations
ZIZKA L (Zizka & Varga, 2021)	2021	Teaching Sustainability in Higher Education Institutions: Assessing Hospitality Students' Sustainability Literacy	J HOSP TOUR EDUC	18

Table 1 shows the 10 most-cited publications by other researchers. The most frequently cited publications are related to sustainability awareness and perceptions of students in higher education.

Distribution of Sustainable Literacy Research Publications at the Higher Education Level by Country and Affiliation Worldwide

Based on the number of documents by country, it is clear that the United States ranks first and has consistently increased its production of research on this topic, followed by the UK in second place, which has also shown a consistent upward trend in research on this topic. Next are Spain, Saudi Arabia, and China. Figure 4 is a visualization of the most productive countries in generating research on sustainable literacy at the higher education level.

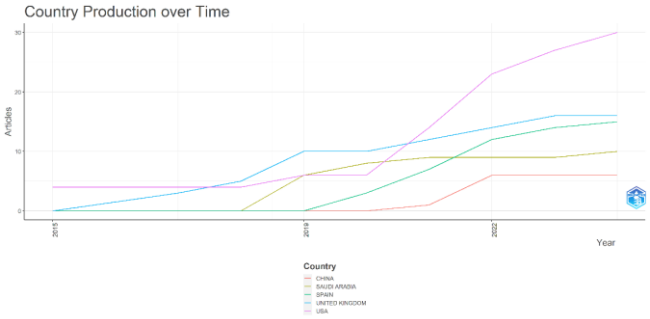

Figure 4. The Number of Documents on Sustainable Literacy Research in Higher Education from 2015-2024 in Several Countries

Based on the number of documents analyzed across various institutions, as shown in Figure 5, it can be seen that UNIVERSITAT POLITÈCNICA DE VALÈNCIA is the institution that has produced the most research on this topic, with 7 documents. It is followed by UNIVERSITY OF MICHIGAN, which ranks second with 6 publications. The next institution is THE EDUCATION UNIVERSITY OF HONG KONG, with 5 publications.

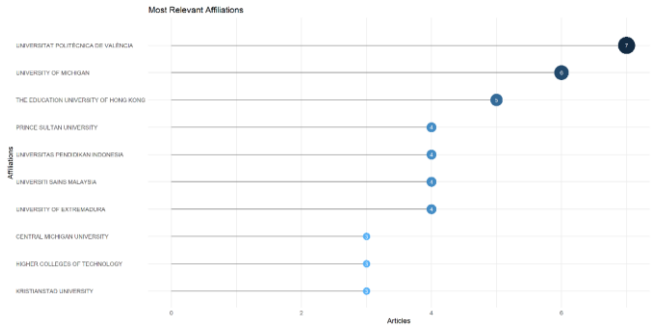

Figure 5. Distribution of Author Affiliations in the Field of Sustainable Literacy Research at the Higher Education Level from 2015-2024.

Most Productive Author in Research on Creative Thinking Skills in STEM Education Worldwide

Regarding the most productive authors researching sustainable literacy at the higher education level, Figure 6 shows the number of authors who have produced the most work on this topic. ALOTAIBI Y is the most productive author in this field, with a total of 2 documents.

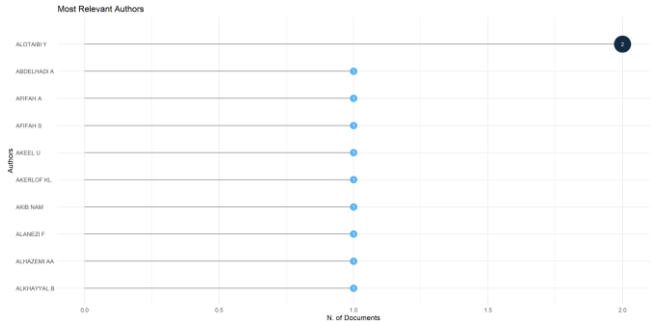

Figure 6. The Number of Articles Written by the 10 Most Productive Authors in Sustainable Literacy Research at the Higher Education Level

Visualization of the results of the sustainable literacy research trend in higher education

Based on the analysis of 44 articles related to sustainable literacy research in the Scopus database, the researchers used the VOSViewer application. Figure 7 shows an overview of research on sustainable literacy. Researchers worldwide have produced five clusters (red, green, yellow, purple, and blue).

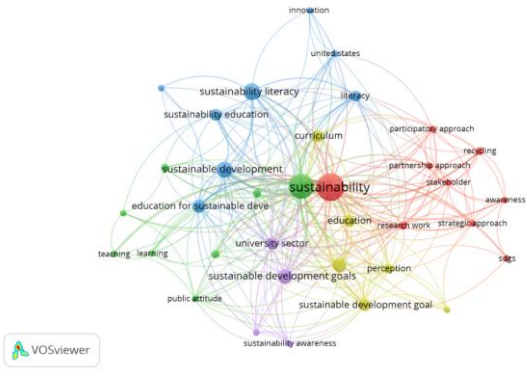

Figure 7. Overview of sustainability literacy research in higher education

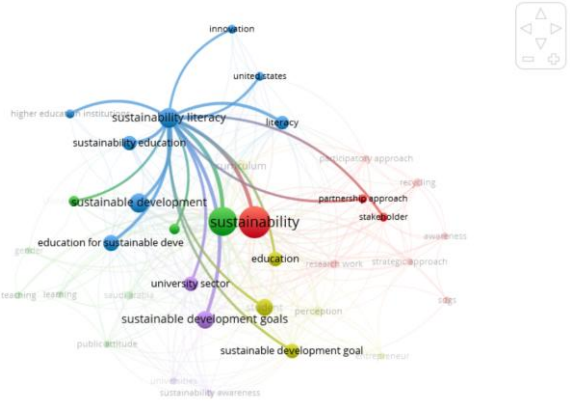

Figure 8. Relationship of sustainability literacy with other domains

Figure 7 shows five clusters of research on sustainability literacy worldwide. The red cluster (containing 9 items) indicates that sustainability literacy is closely related to approaches/strategies, stakeholders, society, and so on. The blue cluster (containing 8 items) shows a close relationship between sustainability literacy and education, innovation, higher education, sustainable education, and so on. The green cluster (containing 8 items) indicates a close relationship between sustainability literacy and attitudes, knowledge, gender, higher education, learning, and so on. The purple cluster (containing 4 items) shows a close relationship between sustainability literacy and universities, SDGs, and sustainability awareness, while the yellow cluster (containing 6 items) shows a close relationship between sustainability literacy and perceptions, education curricula, entrepreneurship, and so on. This result indicates that sustainability literacy generally has a high correlation in the field of education, especially in higher education, where this topic is one of the efforts to achieve the SDGs.

To determine the novelty of research in sustainability literacy, it can be done by outlining the specific relationships between variables. Figure 8 reveals this overview.

Figure 8 shows that research on sustainability literacy is related to sustainable education and higher education. On the other hand, measuring perceptions of sustainability literacy is still a domain that has not been widely studied by many researchers around the world. The publication years of sustainability literacy research by researchers worldwide can be seen in Figure 9.

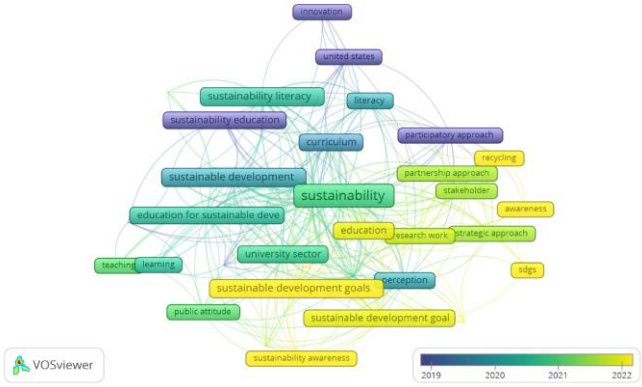

Figure 9. Distribution of themes based on the publication period of sustainability literacy topics

Figure 9 shows that the topic of sustainability, especially in the field of education, has been studied from 2019 to 2022.

Figure 10. Topic Trends in Sustainability Literacy Research

Figure 10 shows that the most frequently used terms in these articles were 'sustainability', 'higher education', 'student', 'sustainable development', and 'university'.

Analysis of sustainability literacy research in higher education from the perspective of measurement tools

Based on the literature review, the following are studies that examine the measurement tools for sustainability literacy, as shown in Table 2.

Table 2. Sustainability literacy measurement tools

Author	Year	Title	Result	Mesurement Tools
(Chen et al., 2022)	2022	Integrating Sustainability and Users' Demands in the Retrofit of a University Campus in China	There is a difference between the perspectives of users and sustainability indicators, which emphasize the importance of sustainable HEI development and lead to the implementation of measures to increase sustainability awareness and guide restructuring.	sustainability assessment tool (SAT)
(Ling et al., 2021)	2021	The Influence of Instructional Delivery Modality on Sustainability Literacy	These results support not only the idea that sustainability can be taught but also that study abroad, regardless of course content, may be at least as effective at increasing sustainability literacy as home campus sustainability-related courses	Multiple choice test adopted from OSU (Ohio State University) & UNC (University of North Carolina)
(Hamdan Alghamdi & El-Hassan, 2019)	2019	Raising Saudi Studentsí (Energy) Sustainability Awareness through ESL ñ Teachersí Thoughts	The findings show a positive outlook on the integration of sustainability topics into the Saudi Arabian ESL curriculum.	Open-ended questions regarding perceptions, opinions, beliefs, attitudes, knowledge, and values
(Lad & Akerlof, 2022)	2022	Assessing campus sustainability literacy and culture: How are universities doing it and to what end?	This study highlights the important role played by institutional priorities in organizations conducting SLAC assessments. While further empirical research is needed to understand how to enhance organizational learning more broadly in universities to improve the impact of SLAC assessments	Sustainability Literacy and Culture (SLAC)
(Marcos-Merino et al., 2020)	2020	Analysis of Sustainability Knowingness, Attitudes and Behavior of a Spanish Pre-Service Primary Teachers Sample.	SCQ is suitable for estimating various dimensions of sustainability awareness among prospective primary school teachers in Spain. Students gave higher scores for sustainability knowledge and sustainability attitudes, particularly in the social dimension. Some gender differences were found in sustainability behavior, with higher scores in the male subgroup for the economic dimension. Correlation analysis revealed a positive relationship between sustainability knowledge and sustainability attitudes, while sustainability behavior was positively related to both constructs but only in the social dimension. These results highlight the need for	Sustainability Consciousness Questionnaire (SCQ)
(Leiva-Brondo et al., 2022)	2022			Assessing Sustainability Knowledge (ASK)
(Syed Azhar et al., 2022)	2022	Spanish University Students' Awareness and Perception of Sustainable Development Goals and Sustainability		The closed-ended questionnaire with dimensions of knowledge or understanding of sustainability, attitudes, and perceptions was adapted from the
(Décamps et al., 2021)	2021	Literacy Students' Attitude and Perception towards Sustainability: The Case of Universiti Sains Malaysia	sustainability education aimed at achieving behavioral change in the Primary Education Degree. A survey study on sustainability awareness and the SDGs shows that many students are aware of the SDGs but have not fully understood the 17 goals and their implementation in daily life. Students who graduate with a degree in life sciences have higher interest and knowledge compared to students without that degree. On the other hand, gender is related to the SDGs, with women showing stronger expectations than men.	Mediterranean Youth Responses Towards Sustainable Development and the Current Crisis, Western Michigan University Student Sustainability Survey, and Ohio State University Campus Sustainability Survey, while other questions were developed by the authors based on information taken from the USM Policy on Sustainability and the USM-APEX Sustainability Roadmap: Aspiring to Meet Global Challenges.
(Kuehl et al., 2023)	2023			Sustainability Literacy Test (SuLiTest)
(Jillani et al., 2022)	2022	Fostering Knowledge of the Sustainable Development Goals in Universities: The Case of Sulitest	The level of positive attitudes and perceptions of students toward sustainability ranges from moderate to high. This study shows a strong positive correlation between students' attitudes and perceptions. Students are able to relate sustainability issues to current situations and have a positive attitude toward the implementation of sustainability programs at USM.	Assessing a bottom-up measure yang berbentuk kuesioner
(Mares-Nasarre et al., 2023)	2023	Exploring sustainability literacy: developing and assessing a bottom-up measure of what students know about sustainability	The results show that active collaboration, stakeholder engagement, and membership in international networks play an important role in sustainability literacy. This analysis also highlights the role of exposure to education in enhancing sustainability literacy and developing a systemic perspective on sustainability.	Questionnaire to measure Sustainability Cognizance (SC) dan Attitude towards Sustainability (AS)
(Alotaibi, 2021)	2021	Assessing sustainability cognizance in higher education institutions	This study develops and tests a sustainability knowledge measure. A questionnaire containing 46 items was developed, which analysis showed to be a valid measure of sustainability knowledge based on clear differences between class levels and majors. The complete questionnaire and the brief scale, which contains 10 interrelated questions, were completed, with advanced-level students and environmental studies majors achieving better results on both compared to first-year students and non-environmental studies students.	Questionnaire
(Malik et al., 2019)	2019	Analyzing Sustainability Awareness and Professional Ethics of Civil Engineering Bachelor's Degree Students		Questionnaire
(Akeel et al.,	2019		The findings show differences in sustainability awareness between students from public and private universities. The findings	Questionnaire with four dimmention: Environmental Sustainability, Social Sustainability, Economic Sustainability, General Understanding of Sustainability

Author	Year	Title	Result	Mesurement Tools	Author	Year	Title	Result	Mesurement Tools
2019)			reveal that the private education sector leads in raising students' awareness of sustainability and sustainable development, while the public sector lags behind. To meet and implement sustainability goals in the country, both sectors need to play their roles by integrating sustainability into the curriculum and modifying policy frameworks.				Education	to increase sustainability literacy within the Nigerian engineering community, possibly through sustainability education interventions.	
	2024	Investigating the Higher Education Curriculum for Sustainable Software Development		Close Questionnaire & sustainability literacy tests (SLT)	(Zizka & Varga, 2021)		Analyzing Sustainability Awareness among Higher Education Faculty Members: A Case Study in Saudi Arabia	This study found that students in STEM fields are more likely to have pro-sustainability attitudes, knowledge, and behaviors compared to those studying arts and business. Furthermore, the research results show a significant difference in knowledge between students and faculty/staff respondents regarding sustainability knowledge and its application, with staff and faculty consistently demonstrating more pro-sustainability knowledge and behaviors.	Sulitest
(Urbaniak et al., 2024)									
	2023			Questionnaire			What difference does one course make?		
(Nițu-Antonie et al., 2023)			The results found that students do not have strong knowledge related to sustainability and ethics, except for students with prior experience in the construction sector. The environmental and social dimensions of sustainability and ethics were identified as key areas to be emphasized in the civil engineering curriculum. Finally, actions to support these principles were also proposed; potential courses where sustainability and ethics concepts could be explicitly integrated were selected, and the inclusion of an environmental budget in undergraduate theses was recommended.				Assessing the impact of content-based instruction on students' sustainability literacy		
		Investigating Students' Sustainability Awareness and the Curriculum of Technology Education in Pakistan							
							An Exploration of the Relationship between Sustainability-Related Involvement and Learning in Higher Education	The research results reinforce the importance of the entrepreneurial model in investigating the determinants of sustainable entrepreneurial intentions and provide new investigative insights for academic research. Furthermore, the empirical research highlights that policies and activities carried out by the government within higher education institutions should be aimed at promoting the benefits of achieving sustainable development goals in Romania at the community level, in order to advance environmental values and thus raise sustainability awareness among both existing and potential entrepreneurs. This will also facilitate the exposure of young people to successful entrepreneurial models, with a stimulating effect on their sustainable entrepreneurial intentions.	
	2021			Questionnaire					
(Manfredi et al., 2021)	2019	Assessing the sustainability literacy of the Nigerian engineering community	71% percent are familiar with the term sustainable development, only 17% know the basic definition of sustainable development, and 12% of them have an idea of how sustainable development is related to software development. Furthermore, this indicates that the current curriculum does not adequately cover specific courses on sustainable development. As a result, educational institutions and universities must raise awareness and understanding of sustainability among students, and thus, they should develop their vision, policies, teaching strategies, research goals, and curricula.						
(Alkhayyal et al., 2019)	2024			Test			Low factual understanding and high anxiety about climate warming impedes university students to become sustainability stewards An Australian case study		
(Erguvan, 2024)	2022	Assessment of sustainability awareness and practice in a campus community		Questionnaire					
(Henderson et al., 2022)				Sustainability Tracking, Assessment & Rating System (STARS)				The analysis of the collected data reveals that the intervention was quite successful in improving material management that is responsible for sustainability.	
		Predicting Sustainable Entrepreneurial Intentions among Romanian Students: A Mediated and Moderated Application of the Entrepreneurial Event Model					Design of a Teaching-Learning Sequence and Its Effect on Self-Efficacy and Perceptions of Prospective Chemistry Teacher Students: An Educational Reconstruction Study of Fire-Retardant Bamboo		
	2017		71% percent of them are unaware of the term sustainability in their respective fields, only 17% of students know the basic definition of sustainability, and 12% of students have only a general idea of how sustainability is related to technology education. It was also found that the current technology education curriculum does not sufficiently cover specific subjects or topics that could help students understand the concept of sustainability. This study highlights the gap in the curriculum offered to build the competencies expected of students in technology education					The results show a lack of understanding of sustainability concepts. Therefore, universities should adopt appropriate approaches to raise awareness by developing sustainability missions at the institutional or departmental level.	
(Pfautsch & Gray, 2017)									
	2022			Questionnaire				The results show that the experimental group students made statistically significant improvements in their sustainability literacy levels, scored better on the posttest, used more sustainability terms and concepts, and identified more sustainability-related challenges and solutions in their essays.	
(Mudzakir et al., 2022)									
		Teaching Sustainable Responsibility through Informal Undergraduate Design	The results show that the majority of students (81%), educators (67%), and practitioners (64%) are unaware of UNDESD. Therefore, there is a need				Teaching Sustainability in Higher Education Institutions: Assessing Hospitality Students' Sustainability	The results found that women reported much higher levels of systems thinking, future thinking, leadership development,	
	2021			Questionnaire					

Author	Year	Title	Result	Mesurement Tools
		Literacy	and activism. Additionally, we found a small negative correlation between sustainability literacy and leadership development as well as activism, suggesting that there may be a tipping point where increased knowledge about climate change and sustainability issues leads students to be less likely to engage in leadership and activism behaviors. The implications of this article are for sustainability education pedagogy in higher education. Gender and age of students significantly affect their perceptions of climate warming. While their self-assessed understanding of climate warming is generally high, factual knowledge about climate warming is low. Few students are aware that climate warming is already occurring and that it is primarily caused by human activity. The most prominent emotions are fear, sadness, and anger, which predict widespread helplessness and fear about the future. The results show that students' self-efficacy improved to 88.9%, which falls into the very good category. The percentage of students' perception ability increased to 92.8%, which falls into the agree category. Thus, designing sustainability-oriented learning stages on fire-resistant bamboo can improve self-efficacy and perceptions among prospective chemistry teacher students. The design of the learning stages can help prospective teacher students integrate chemistry concepts with technology engineering in their teaching. The use of sustainable materials in the learning stages can foster sustainability literacy among students and support the creation of sustainability-oriented education in higher education environments. The results show high student interest and strong support for sustainability in their academic and professional careers. More than 67% of respondents rated sustainability as very important for their professional life. Higher education institutions have the opportunity to teach sustainability concepts. While research promotes the integration of sustainability into all courses, our results indicate that students' sustainability knowledge can be enhanced in a single intensive course. Further studies should be conducted to ensure retention and engagement.	

Discussion

Based on the results of bibliometric analysis, research on sustainability literacy was most frequently published in 2022 and started to increase in 2019. Although it has experienced fluctuating growth, research on sustainability literacy remains a trending topic among researchers worldwide. This can be seen from the high number of citations in articles on sustainability literacy. As shown in Table 3, the three most cited publications are articles investigating and analyzing students' sustainability literacy perceptions, with 48 citations (Malik et al., 2019), 38 citations (Alkhayyal et al., 2019), and 34 citations (Leiva-Brondo et al., 2022). These results illustrate that research on sustainability literacy is still focused on investigating sustainability literacy profiles, with few researchers exploring steps to facilitate and enhance sustainability literacy. Although many researchers have agreed on recommending that sustainability literacy be included in higher education curricula (Hamdan Alghamdi & El-Hassan, 2019; Jillani et al., 2022) and its implementation in teaching (Chen et al., 2022; Lad & Akerlof, 2022; Ling et al., 2021). In terms of the journals publishing this research, the Sustainability Journal is the most frequent publisher on this topic, with 16 publications. This is likely because the journal is an open-access international and interdisciplinary scientific journal on technical, environmental, cultural, economic, and social sustainability, providing an advanced forum for studies related to sustainability and sustainable development.

From the perspective of countries that have made significant contributions to research on sustainability literacy, the USA is the most productive country, followed by the UK in second place, which has also consistently seen an increasing trend in this topic. This is followed by Spain, Saudi Arabia, and China. The USA is a large country with a high commitment to the development of interdisciplinary research, particularly research on sustainable development, which remains a global agenda. On the other hand, the USA has proven to have a research community committed to driving discussions on sustainable development. This is also due to serious issues within the USA itself, as it is one of the countries

with the highest levels of industrialization and CO_2 emissions, alongside China (Žalėnienė & Pereira, 2021). This issue is also one of the reasons why the USA has a strong commitment to environmental sustainability.

From the perspective of author affiliation, Universitat Politècnica De València is the institution that has produced the most research on this topic, with 7 documents. Meanwhile, ALOTAIBI Y is the most productive author in this research area, publishing 2 documents. Alotaibi is a researcher from the Department of Computer Science, College of Computer and Information Systems, Umm Al-Qura University, Makkah, Saudi Arabia. Saudi Arabia is one of the top five countries with the highest productivity in research on this topic, making it highly likely that researchers from this country are among the most productive in this field. Furthermore, Saudi Arabia is committed to achieving the 2030 Vision agenda, which continuously encourages researchers in the country to conduct studies on sustainable development, with a focus on higher education to realize this vision (Essa & Harvey, 2022; Sharabi, 2024). Additionally, the number of citations based on their Google Scholar profile is significantly high, with 3790 citations (https://scholar.google.com/citations?user=Ds7dwuUAAAAJ&hl=id&oi=ao).

Research on sustainability literacy is strongly linked to sustainable development in higher education, particularly in the curriculum. Sustainability literacy in higher education has been one of the key recommendations put forward by several researchers around the world. This is because, based on literature reviews, students need to be provided with knowledge and understanding of sustainability literacy in order to develop a positive attitude toward the environment (Syed Azhar et al., 2022). Additionally, integrating sustainability literacy into the higher education curriculum is a recommendation that has been widely suggested by many researchers globall (Alotaibi, 2021; Hamdan Alghamdi & El-Hassan, 2019; Jillani et al., 2022; Malik et al., 2019; Mares-Nasarre et al., 2023). This is in response to the low levels of sustainability attitudes and knowledge among students (Alkhayyal et al., 2019). The issue of gender is an interesting aspect in the measurement of sustainability literacy (Leiva-Brondo et al., 2022; Marcos-Merino et al., 2020; Pfautsch & Gray, 2017). The findings indicate the importance of understanding gender differences in the sustainability attitudes and knowledge they possess. Although, according to the analysis, women show more concern than men (Leiva-Brondo et al., 2022). men actually have better capabilities in certain aspects, such as economic sustainability (Marcos-Merino et al., 2020).

Research on sustainability literacy, based on the analysis, shows numerous studies comparing students from affiliations outside non-environmental studies (Kuehl et al., 2023). However, many researchers also examine sustainability literacy in other fields, such as arts (Urbaniak et al., 2024), ESL (Hamdan Alghamdi & El-Hassan, 2019), business and entrepreneurship (Nițu-Antonie et al., 2023), and pre-service elementary school (Marcos-Merino et al., 2020). Although the studies consistently show that sustainability literacy among students in environmental studies tends to be better (Urbaniak et al., 2024). researchers worldwide still recommend that education for sustainable development, particularly the development of sustainability literacy, should be introduced to students in higher education. Teaching that emphasizes sustainability literacy is also a key recommendation from researchers globally (Alkhayyal et al., 2019; Henderson et al., 2022). There is a need to develop effective approaches and strategies to improve sustainability literacy in higher education.

Measuring sustainability literacy is important as an effort to determine adequate and appropriate sustainability literacy skills aligned with the dimensions of sustainability literacy. Many studies use questionnaires and tests to measure sustainability literacy. Some of the tests used by researchers worldwide include SAT (Chen et al., 2022), SLAC (Lad & Akerlof, 2022), ASK (Leiva-Brondo et al., 2022), STARS, and Sulitest (Décamps et al., 2021; Zizka & Varga, 2021). Questionnaires like SCQ (Marcos-Merino et al., 2020) have also been used. Sulitest is one of the recommended tests for measuring sustainability literacy. Sulitest is an

international MSP (multiple-stakeholder partnership) led by an NGO accredited by the UN and coordinates a community of various stakeholders: UN bodies, academic and professional networks, universities, and companies. Sulitest defines its main mission as expanding knowledge, skills, and sustainability mindsets that motivate individuals to build a sustainable future and enable them to make the right and effective decisions for this purpose. Sulitest offers a key tool: the online Sustainability Literacy Test, designed to enhance and map knowledge of various sustainability topics, covering the 17 SDGs (Décamps et al., 2021). On the other hand, Sulitest serves as a guideline for higher education to assess whether they are producing graduates who are sustainability literate, while also engaging various stakeholders to accelerate the integration of sustainability into higher education standards across disciplines (Décamps et al., 2017; A. M. Mason, 2019).

Conclusions

The results show that the last two years (2022) had the highest number of studies on this theme. It was revealed that the United States is the most country in producing research in this area, followed by the UK, Saudi Arabia, Spain, and Australia. Sustainability (Switzerland) was identified as the journal that published the most articles on the topic and is the most cited. The most frequently used terms in these articles were "sustainability", "higher education", "student", "sustainable development", and "university". The results of the research analysis show that there is a variation in evaluation tools used by researchers worldwide to measure sustainable literacy. However, generally, researchers around the world use questionnaires and tests to assess sustainable literacy. The recommendation in this study is the need for measuring sustainability literacy among students to understand their sustainability literacy profile, which can serve as a foundation for sustainable learning at the higher education level.

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