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# Are We Talking about Green Skills or Sustainability Competences? A Scoping Review Using Scientometric Analysis of Two Apparently Similar Topics in the Field of Sustainability

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**Abstract:** The labor market is facing accelerating changes due to ecological challenges and the related increasing efforts towards sustainable development. Preparing learners for the world of work now requires an understanding of what skills workers will need to adequately address these changes. To deal with this issue, the research community has started to define "sustainability competences" and "green skills" to support educationalists and decision-makers to better manage the impact of sustainability on future jobs. However, in the current literature, the difference between "sustainability competences" and "green skills" is not clear. The aim of this article is to highlight the differences between the two concepts in order to support the dialogue between the various disciplines that address these topics. This paper is a scoping review that provides an outline of the scientometric analyses of publications in the field of sustainability, from the earliest in 1998 up to July 2023. Although the terms are interrelated, using the R package for analysis shows that "green skills" tends to refer more to specific environmental technical skills, while "sustainability competences" are primarily defined as key competences to promote the different dimensions of sustainability, i.e., competences useful for holistic human development

**Keywords:** green skills; sustainability competences; sustainability; education for sustainable development; future jobs; scoping review



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## 1. Introduction

When it comes to sustainability issues, the global community is looking for solutions that encompass the holistic development of people and of the planet. Sustainability issues impact across sectors and disciplines and require the reconsideration of organizational practices as well as the way students and workers are prepared for the labor market and future jobs [1–4]. For this reason, educational institutions and policy makers are called upon to take the lead towards more sustainable lifepaths [5]. Education for Sustainable Development (ESD), which is Goal No. 4.7 of the United Nations' 2030 Agenda, notably deals with two issues. The first relates to the different interpretations of the meaning of "competences". One possible way to equip workers and students with the knowledge, skills, and awareness required for sustainability is through competence-based education and training [6,7]. The success of competence-based education is probably due to the economic value that education has acquired and the need to quantify educational outcomes via specific measures [8]. On the one hand, the focus on competences corresponds to the drive to increase employment in order to boost the rate of growth and global competitiveness [9]. Therefore, some scholars define competence according to a neoliberal behaviorist perspective and as a personal characteristic related to effective or superior task

performance [8,10]. On the other hand, competence-based education seeks to break away from the traditional methods of knowledge transfer and to integrate new methods based on experience, attitude, and reflection [11,12]. In this case, authors define competence as the ability of people to mobilize their resources appropriately in specific contexts [13] and to improve their functioning [14]. In this transformative approach, competences are seen as a prerequisite for achieving holistic wellbeing and development [15]. In international documents, competences are described as a set of knowledge, abilities and attitudes that people need to meet their professional, personal, and social needs [16,17]. In the context of the learning compass, OECD defines competences as the ability to combine knowledge, skills, attitudes, and values to achieve the holistic wellbeing of the individual [17]. This controversy leads, on the one hand, to a primary focus on employment, an issue that is particularly relevant for countries that want to increase their competitiveness, with the risk of disregarding the holistic idea of sustainable development and the integral wellbeing of socio-ecological systems [14,18]. On the other hand, competences and skills [15], if understood in a transformative sense, could be the central pedagogical *dispositif* [19] to deal with today's challenges and shape the future [16].

The second aspect of education and training for sustainability is the complexity of sustainability as a field of research, even if at present, the term sustainability assumes different meanings [20,21]. The concept of sustainability arose in the scientific literature in the context of forest management [22], i.e., in the environmental field, and from 1972 became more widely used in other fields after the publication of "The Limits to Growth" [23]. Today, sustainability could be defined as a normative concept that represents a desirable vision for society [20]. In the Brundtland's report there is an established definition of sustainable development [24], however the positions of authors on how to achieve this differ (see, e.g., sustainable development vs. sustainable growth). In the 1990s, Elkington [25] developed the Triple Bottom Line (TBL) model, an accounting framework that includes three dimensions of business performance—environmental (planet), social (people), and economic (profit)—as a method to measure sustainability in business. Currently, scholars argue that sustainability involves several dimensions, including the three mentioned above and also the dimension of institutional responsibility, as shown by the Donut Economy model [26], which combines the concept of planetary boundaries, originating from Environmental Sciences [27], with the concept of social boundaries, as well as the 17 sustainable development goals of the 2030 Agenda [28], which addresses global challenges via 17 interconnected goals. There are also sustainability models that relate to other subject areas, such as ESD [29], GreenComp [30], and sustainability education [31].

The approaches outlined in the previous paragraph are just some of those found in the literature on sustainability. This underlines the multidimensionality of this topic and the complexity of integrating the different disciplines and approaches that deal with it, considering that each subject investigates a specific aspect of sustainability and that it is difficult to take into account all the different links that exist between them and that may at times contradict each other. Our study does not aim to delineate the epistemological boundaries of sustainability as a transdiscipline, but rather to focus on the need to develop shared meanings that are necessary to provide concrete answers to today's challenges, and thereby at least to outline a common language that enables the development and articulation of education and training as key factors for alternative future scenarios. When we speak of transdisciplinarity, we do not exclusively mean the need for cooperation between experts and stakeholders from different fields [32], but the creation of an epistemology complementary to the disciplinary approaches, which includes the different levels of phenomena and the connections and interactions between them [33] and which defines the structure and patterns that connect sustainability according to the ecosystemic approach [34].

Due to the current importance of promoting sustainability within the labor sector in our society, it is essential to incorporate the concept of "green jobs" when discussing future employment trends [35,36]. While there is no current common definition, green jobs generally refer to jobs related to environmentally friendly production or services, such

as eolic production, decarbonization production processes, and communication services related to environmental sustainability. The term "greener jobs" is also discussed in this context, referring to any type of work that minimizes its environmental impact [4]. In addition, future jobs include those that relate to the social dimensions of sustainability, such as caring jobs and innovative as well as creative jobs that use technology and digital development to achieve sustainability in all its dimensions [2]. Finally, we include the concept of decent work in the discussion on sustainability in the labor sector, which is Goal No. 8 in the 2030 Agenda. In view of this, the above-mentioned jobs are not necessarily associated only with better working conditions in terms of job quality, labor rights, job security, or personal satisfaction.

Considering the complexity of future jobs, it is difficult to identify the related competences or skills needed to achieve sustainability. The term "skills" is sometimes used as a synonym for "ability" and sometimes as a synonym for "competence" or "competency". In line with our findings, in this paper we use "skill" to denote more technical, specific meanings and "competences" to denote more transversal meanings [13]. We have made no distinction between "competence" and "competency", as during our research we found that these terms were largely used interchangeably. We generally use the term "competence" to maintain a broader and more general outlook which includes the different disciplines, even if some authors referred to "competency". Recently, scholars have attempted to identify the taxonomy of green skills and sustainability competences [36–41], and, more recently, to assess these competences, their related learning outcomes [31,42], and their connection to other sustainability dimensions [43]. In education, taxonomy is used to categorize educational objectives, which runs the risk of creating a rather static and reductionist view of human beings [6]. By contrast, taxonomy is believed to be useful in defining global objectives and guiding teachers and educators in the assessment of learners, even if the indeterminacy of learning outcomes may make it difficult for educators to incorporate them into context-specific situations, and not all learning outcomes can be made explicit or operationalized to encompass the needs of all learners. Nevertheless, the taxonomy of competences can be a great support in creating student-oriented curricula [6].

In the scientific literature and in international documents, the proficiencies needed for achieving sustainability are sometimes referred to as "sustainability competences" and sometimes as "green skills". These are two similar concepts, and in international and European documents, they appear to be used interchangeably, as is the case in the "GreenComp European Framework" [30]. For instance, the Cabral, the Commonwealth Department of Education, and the Employment and Workplace Relations (DEEWR) states that "green skills, or skills for sustainability, are the professional and vocational skills, as well as the generic skills (such as sustainable approaches, innovation and problem solving) required for new green jobs and the greening of existing jobs across all industry sectors as a response to climate change and sustainability imperatives" [16]. In contrast, sustainability competences are defined by UNESCO as the capabilities required to enable and empower individuals to reflect on their own actions by taking into account their current and future social, cultural, economic, and environmental impacts from both a local and a global perspective [28]. Therefore, there is a lack of evidence on whether the two concepts are different or whether they follow the same representational scheme with regard to sustainability. The purpose of this paper is to explore these two concepts in order to provide greater clarity for future research on sustainability and education for sustainability as well as to highlight the need for increased dialogue between disciplines and transdisciplinary studies on these topics, which are fundamental to support policies and sustainable education and training. Indeed, it is necessary to further define and integrate them into education and learning agendas in order to shape alternative scenarios that encompass sustainable complexity.

## 2. State of the Art

In the scientific literature, there are already several reviews on green and/or sustainability proficiencies in different fields, from economics to education. However, they mainly focus on one of the concepts and none of them compare these seemingly similar topics [28,44–48]. Previous literature reviews have used systematic or qualitative methods related to sustainability competences [45] and descriptive or thematic analyses on green skills [44]. They also focus on different areas, e.g., teacher or student education [46,47] or the management of sustainability competences [48], as well as on the topic of green skills [44]. In this section, we provide a brief overview of the different taxonomies and perspectives on green skills and sustainability competences based on the most cited and prolific articles and authors on these topics.

Currently, Vona et al. define green skills as subject-specific, e.g., for Engineering and Science or for operations management and monitoring [36]. They go beyond previous research in which these authors included routine and non-routine skills, such as cognitive, interactive, and manual skills [37]. Their earlier study concurs with Pavlova, who considers green skills to include Science, Technology, Engineering, and Mathematics (STEM) skills as well as soft skills, such as environmental awareness, entrepreneurial skills, team-working, creativity, problem-solving, and analytical thinking skills for holistic and interdisciplinary approaches [49]. This broader approach to green skills is in accordance with Kwauk and Casey, even though these authors tend to be critical of studies that conflate green skills and STEM. In contrast, they state that "skills for green jobs", "green life skills", and "skills for green transformation" should be integrated together [38]. They also highlight the risk of focusing only on reskilling and upskilling processes and adopting an instrumental view of education instead of a transformative one in line with the capability approach [14,15].

On the topic of sustainability competences, on the other hand, we found a broader perspective overall, which is more coherent according to some authors [42], although there is not yet a common definition for all of them [31]. There are a few specific references to the environment, such as Glasser suggesting that ecological literacy is necessary and should be included in sustainability competences [50]. Even if the focus is not on the environmental dimension, scholars link key competences to green jobs and sustainable development. One of the key authors on this topic, Armin Wiek, which was taken up by UNESCO in Education for Sustainable Development [29], suggests that the core sustainability competences are

- Systems thinking competence;
- Future-orientated thinking (or anticipatory) competence;
- Value-based thinking (or normative) competence;
- Strategic thinking (or action-orientated) competence;
- Collaboration (or interpersonal) competence.

This list does not include any specific technical skills, environmental values, or literacy [40,41]. Recently, more key competences have been added to this list: intrapersonal competences [39,51], implementation competence [39], and integration competence [45]. This taxonomy of sustainability competences is similar to Cabral's taxonomy of green skills [44], which includes green awareness as knowledge about the impact of human behavior on the environment to be included in self-awareness and self-care typical of intrapersonal competence [45]; green knowledge, i.e., knowledge about the environment and collective responsibility necessary for sustainable development in line with the ESD framework and No. 4.7 of the Sustainable Development Goals (SDGs); green skills, which represent a practical application of theoretical knowledge, such as implementation competence [39]; green skills, i.e., an individual's capacity to integrate theoretical solutions to real environmental challenges in line with strategic thinking or action-orientated competence [40]; green attitude, i.e., the psychological tendency expressed via the beliefs regarding the natural environment similar to value-based thinking (or normative) competence [40]; and finally, green behavior. This is behavior that causes an employee to initiate

action to protect the environment, which may not only be individual but can also involve participative, collaborative activities that require interpersonal competences [40].

*The Research Questions*

Given the lack of clarity about what scholars mean by "green skills" versus "sustainability competences" and the fact that these topics tend to be treated as synonymous in some research on sustainability, such as the "GreenComp European Framework" [30], we decided to determine their relevance in the scientific literature of different disciplines based on their annual academic production [52]; to explore their general conceptual structure quantitatively by referring to the research areas and most relevant keywords and themes [52]; to investigate the social structure of a particular scientific community in a quantitative perspective based on the most productive countries and their associated collaboration networks; and to compare different intellectual topic structures on the most impactful authors and their associated co-citation networks, based on productivity and the quantitative index [52].

Therefore, the main research questions are

- What are the differences and similarities in the annual scientific production, the most productive countries, the associated collaboration networks and the countries' production over time, the research areas and their associated trends, the authors and their associated co-citation networks, and the thematic map of "green skills" and "sustainability competences" in the field of sustainability?
- What are the preliminary definitions of these sustainability skills/competences and what patterns connect these two similar topics?

## 3. Methods

### *3.1. Scoping Review via Scientometric Analysis*

A scoping review provides an initial indication of the nature of the available literature on a particular topic [53]. This type of review is useful for identifying gaps as well as emerging evidence, while the key concepts are heterogeneous and still unclear, and for supporting future research in this area [54]. For a scoping review, it is generally recommended to use the PCC acronym (Population, Concept and Context, according to Peters et al. [55]). However, we chose not to focus on a specific target or age group since the scientific literacy on the concepts we are focusing on—"green skills" and "sustainability competences"—is low, and the general commitment to lifelong and lifewide learning, education, and training concerns all sectors and disciplines. For this reason, and considering that in a competence-based society, several disciplines—from education to management—are involved in identifying future competences, we decided not to limit this study to one discipline, but to look at the differences between them via a transdisciplinary perspective [33]. For the same reason, we chose to define the concept of sustainability broadly, rather than focusing solely on sustainable development, which often implies the process of gradually making something better or more advanced. Scholars use different review approaches to understand outcomes. Among these, bibliometrics has the potential to introduce a rigorous, transparent, and reproducible review process based on statistical measurement that presents the "big picture" of extant research to a broad audience [52]. The use of bibliometrics is useful for investigating fragmented and contested research and identifying trends, previously explored themes, shifts in the disciplinary boundaries, and the most prolific scholars [52]. In this paper, we have used the Bibliometrix R Package 4.1.3(K-Synth Srl, Academic Spin-Off of the University of Naples Federico II, Italy) [52], a web-based application for conducting scoping reviews, mapping, and analysis of the scientific literature. However, the strength of bibliometric network visualization also lies in the simplification it offers, even if the simplification may at times imply a loss of information; for instance, information on the specific contexts and reasons for citing someone [56]. Despite this criticism, our type of analysis is useful for gathering evidence for a broad definition of the two interrelated topics.

### *3.2. Data Collection*

This study compares two different research topics: one related to sustainability competences, and the other to green skills. The aim is to provide an overview of the peer-reviewed literature in the interdisciplinary databases. Scopus and Web of Science (WoS) were identified as the largest interdisciplinary databases for the peer-reviewed literature, spanning different countries around the world. We only considered the literature in English. We excluded Scopus because we wanted to compare different disciplines such as Education, Psychology, and Social Sciences, but in Scopus, these fields are amalgamated in the general area of Social Sciences. WoS distinguishes between Education, Social Sciences, and other research fields, which was important to define the conceptual structure of green skills and sustainability competences.

To identify the keywords to employ, we chose the keywords "green" in the first instance. In the second search, we looked for the keywords "sustainability" and "sustainable". We then added further terms to outline the main concepts of this study as defined in the PCC acronym [55]. In the context of competence-based education and training, many terms are used for competence as a personal capacity, e.g., "skill" and "capability". For this reason, we used the Boolean OR and the advanced search for spelling variations of the singular and plural terms. For the first search, the following filters were chosen: "green skill*" OR "green capabilit*" ORI "green competenc*". For the second search, we used the same filters but replaced "green" with "sustainab*" (in some databases, we were able to use the advanced search function for spelling variations, hence the use of the * asterisk and truncated words such as "sustainab*"). We excluded "capacity" as a synonym for "skills" because our research defines personal competences in terms of the OECD's general definition, i.e., the ability to combine knowledge, skills, attitudes, and values to achieve the holistic wellbeing of the individual. However, in relation to green and sustainable topics, "capacity" is often associated with the instrumental, environmental, and medical capacity of vehicles, machines, or projects, rather than with personal competences. Indeed, while reviewing the titles and abstracts of papers related to the keywords "green capacit*" (41 in total), we found that none of them mentioned personal skills. In addition, the results relating to "sustainab* capacit*" (190 in total) were not related to the topic of our research (searched in July 2023). We then applied the following exclusion criteria:

- Languages other than English
- Non-peer-reviewed documents: we restricted the search to academic papers such as articles, early access articles, and review articles to ensure higher quality [57].

We then exported the records to a BibTeX file with information on the author, title, source, abstract, and cited references. For green skills, 146 records were exported, and for sustainability competences, 374. We exported these to the Bibliometrix R Package [52] for two different scientometric analyses, which were then compared. Figure 1 shows the stages of the two parallel queries.

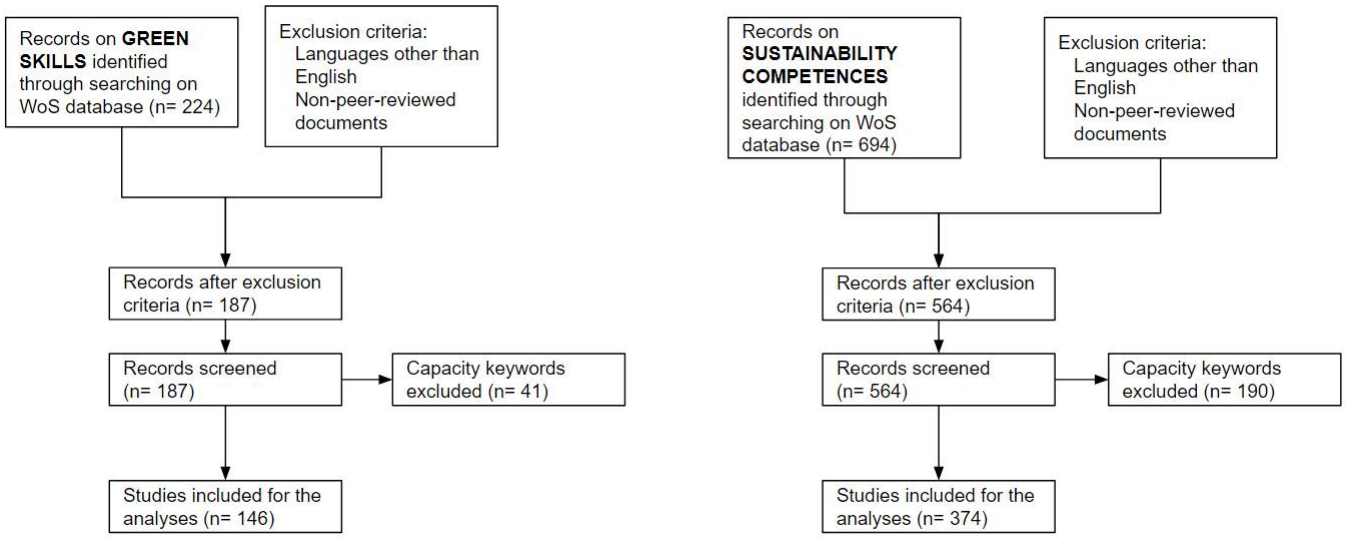


**Figure 1.** Selection of sources of parallel scoping reviews on green skills and sustainability competences, adapted on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) structure [58].

### *3.3. Data Analysis*

With the Bibliometrix R Package, it is possible to perform a descriptive and network analysis of a bibliographic data framework in order to reveal the social, conceptual, and intellectual structures as understood by Aria and Cuccurullo [52]. First, the analyses of the scholarly production of countries and their associated collaborative networks reveal how authors and countries interact with each other. Second, the conceptual structure is useful to identify the main themes and research field of a topic, e.g., via network analyses that evaluate the relationships between words or concepts, such as the thematic map. Finally, the intellectual structure includes the relationships between authors and their impact on the scientific community, e.g., via the analysis of the co-citation network. To obtain a comprehensive overview of the topics, the analytical steps carried out in this study included some performance analyses to assess the impact of research activity, while the others were based on science mapping to visualize the results [59]. The specific steps are listed below:

- Annual scientific production
- The most productive countries, the associated collaboration networks, and the countries' production over time
- The research areas and their associated trends
- The most relevant authors and their associated co-citation networks
- The main keywords and the thematic map

First, we performed a descriptive analysis on the annual scientific production to highlight the increase, decrease, and turning points [52].

The second set of results we analyzed were the most productive countries and their associated collaboration networks, i.e., the links between authors and co-authorships were calculated using papers where at least one co-author is from a different country [52]. In addition, we analyzed the countries' scientific production over time by evaluating the relative proportionality of the number of publications of the first seven countries with the highest current productivity.

The third set of results we analyzed were the research areas and their associated annual trends, focusing on the most productive disciplines, the relationship between them, and the production of each country. Defining the disciplines and research areas of a study is a complex and controversial issue, but for this scoping review, it was necessary to compare the conceptual structures, so we decided to use the WoS classification of subject areas.

The fourth set of results we analyzed were the most prolific authors who have a greater impact on research based on the quantitative indexes and the corresponding co-citation networks. Quantifying the scientific output of a researcher and his or her influence on a single topic is a fundamental as well as a controversial issue. Specifically, it is difficult to compare the authors of two different topics, but for the research purpose at hand, it is necessary to understand whether authors dealing with the first topic are the same as those of the second, and what the differences are between them. For this reason, we reflected on how to evaluate author relevance. One of the most common indices for assessing author relevance is the h-index, but it does not take into account the time factor, self-citations, or the difference in the number of annual publications between one scientific field and another, nor between a more or less popular topic. Indeed, evaluating an author according to his/her productivity is reductive because every discipline has different dynamics. Therefore, we also focused on co-citation networks, which are calculated when two articles are cited in a third article [52]. Furthermore, with R packages, it is possible to investigate an author's impact based on the h-index, g-index, and m-index. Bornmann et al. [60] recommended using two kinds of indices to measure the research impact: one related to the number of publications (e.g., h-index or g-index), and the second related to the impact of the papers (e.g., a-index or m-index). We therefore extracted the lists of the top ten most relevant authors for each index (h-index, g-index, and m-index) in order to compare the results of the two topics, "green skills" and "sustainability competences".

The last step of the data analyses we conducted was a keywords analysis and thematic analysis to better understand the conceptual structure of each topic. First, we extracted the frequency of the authors' keywords using the R package [52]. Then, we manually combined similar terms that occurred in the same list, i.e., "sustainability" and "sustainable", which allowed us to analyze them. Thereafter, we used the same procedure for Keywords Plus, i.e., words or phrases that appear frequently in the titles of an article's references and not necessarily in the title of the article or as author keywords [61]. After that, we conducted a thematic analysis, a combination of the performance analysis and science mapping, to show the main theme of the topics, with each author's keyword assigned to only one theme, which is shown in a different cluster.

Finally, in the last section of this paper, we discuss, interpret, and compare the records of these two different topics: the first on green skills, and the second on sustainability competences.

## 4. Results

### *4.1. Annual Scientific Production*

An analysis of the annual scientific production makes it possible to understand the increasing relevance of studies on green skills and sustainability competences. The first publications on green skills in the WoS database date back to 1998 and both refer to Business and Economics; they are the result of a collaboration between authors from the UK and Belgium [62,63]. Figure 2 shows increasing relevance from 2012 onwards, with three jumps possibly related to turning points [52]: the first in 2016, then 2020, and 2022. On the topic of sustainability competences, the first publication in WoS was in 2002, which was again related to Business and Economics and was the result of a collaboration between authors from the US and Canada [64]. Figure 2 shows increasing relevance from 2007 onwards, with a larger increase since 2015 and two inflection points in 2019 and 2021.

### *4.2. Countries, Associated Collaboration Networks, and Production over Time by Country*

According to the Bibliometrix analysis, the highest number of publications on green skills come from China (22 publications in total), Malaysia, (20), South Africa (13), the UK (11), India and the US (7 each), and Italy, Pakistan, Poland, and Spain (6 each). The highest number of publications on sustainability competences come from Spain with a total of 60 publications, China with 36, the US with 35, the UK with 28, Australia with 18, Sweden with 17, and Germany and Canada with 15 publications each.

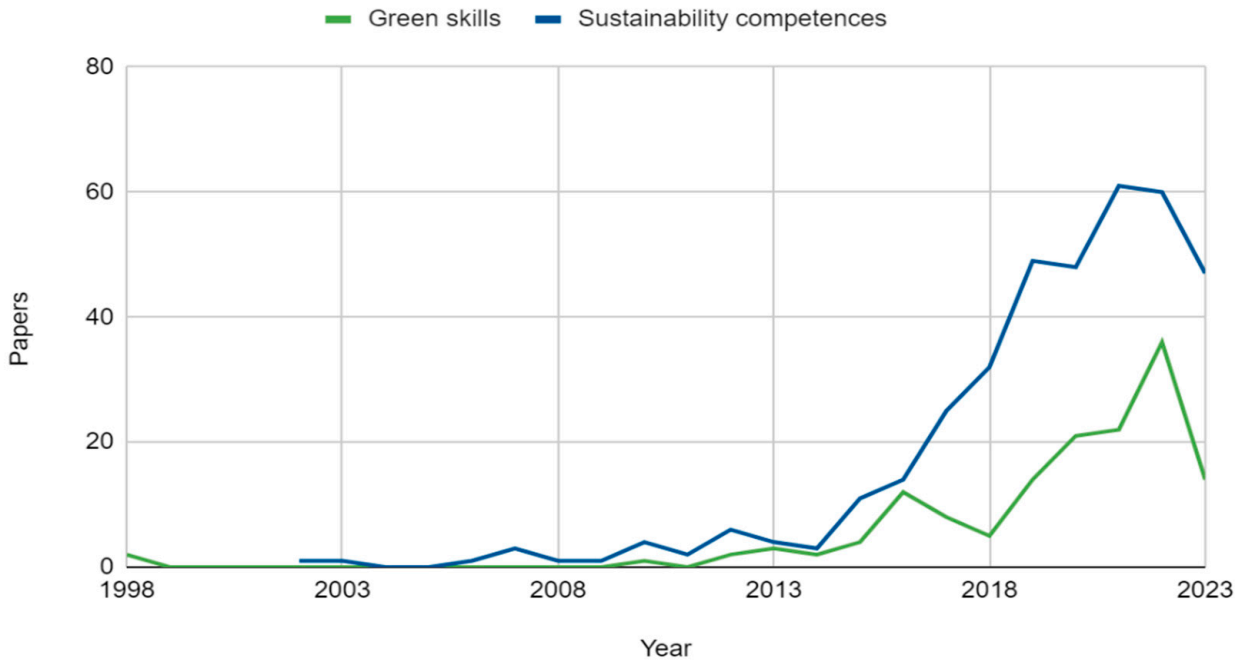


**Figure 2.** Annual scientific production of papers on green skills and sustainability competences in WoS, from 1998 to July 2023.

The scientific production of a country and their associated collaboration networks need to be studied to understand the social structure of a scientific topic over time. In the WorldMap (Figures 3 and 4), it is easy to see which countries have a greater interest in the topic of green skills (Figure 3) and which are more interested in sustainability competences (Figure 4) by the intensity of the color, which is proportional to the number of publications. In this way, the social structure is highlighted by the productivity of countries, and the collaboration networks were also calculated based on publications where at least one co-author is from a different country. As can be seen, green skills seem to involve less cooperation and focus on the central role of China and other Asian countries, while sustainability skills seem to be explored more in Europe and North, South, and Central America. The differences in social structure between these two similar topics are presented in the discussion below. The following section also discusses social structure over time, which allows for comparison with the annual scientific production using the graphs in Figures 5 and 6. These graphs show the production of countries over time, with the number of articles proportional to the number of publications, in contrast to Figure 2, which shows the frequency of publications. It is interesting to observe that the UK and US show similar trends for green skills. The first article on green skills appeared in 1998, the second in 2013, while Chinese, Italian, and South African studies emerged more widely in 2016, Malaysian studies in 2017, and more recently, Pakistani studies appeared in 2020. Regarding sustainability competences, US studies were published first, followed five years later by UK and Chinese publications. Spanish and Swedish studies appeared in 2009 and were characterized by strong growth, followed by Australian and German publications in 2011 and 2014, respectively.

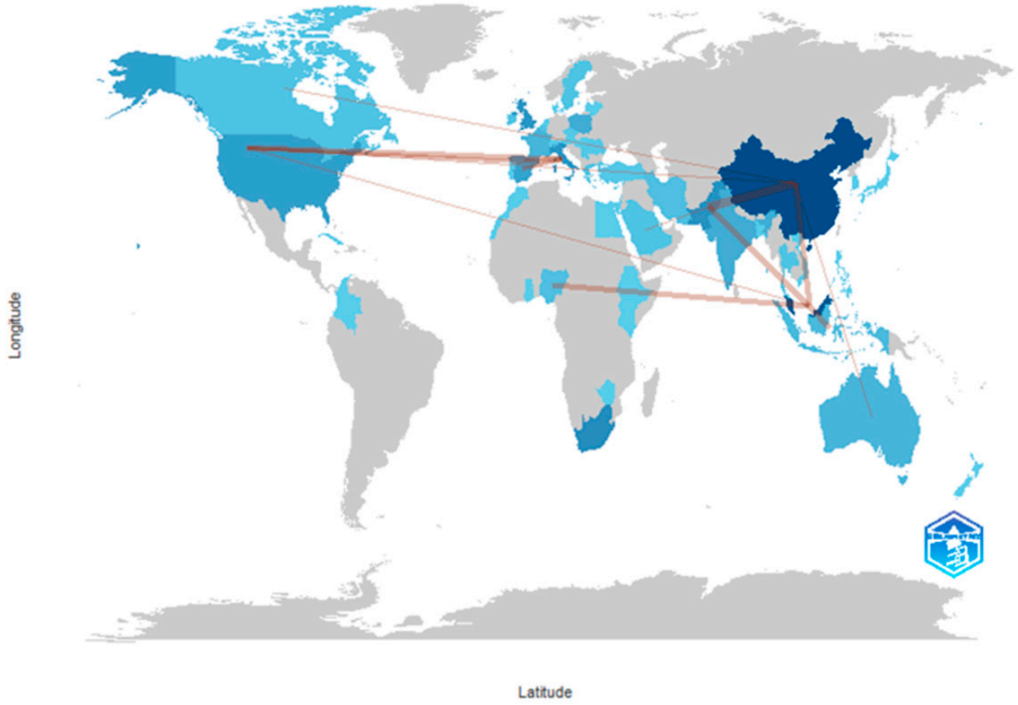


**Figure 3.** Collaboration WorldMap on green skills papers in WOS. The intensity of the color is proportional to the number of publications.

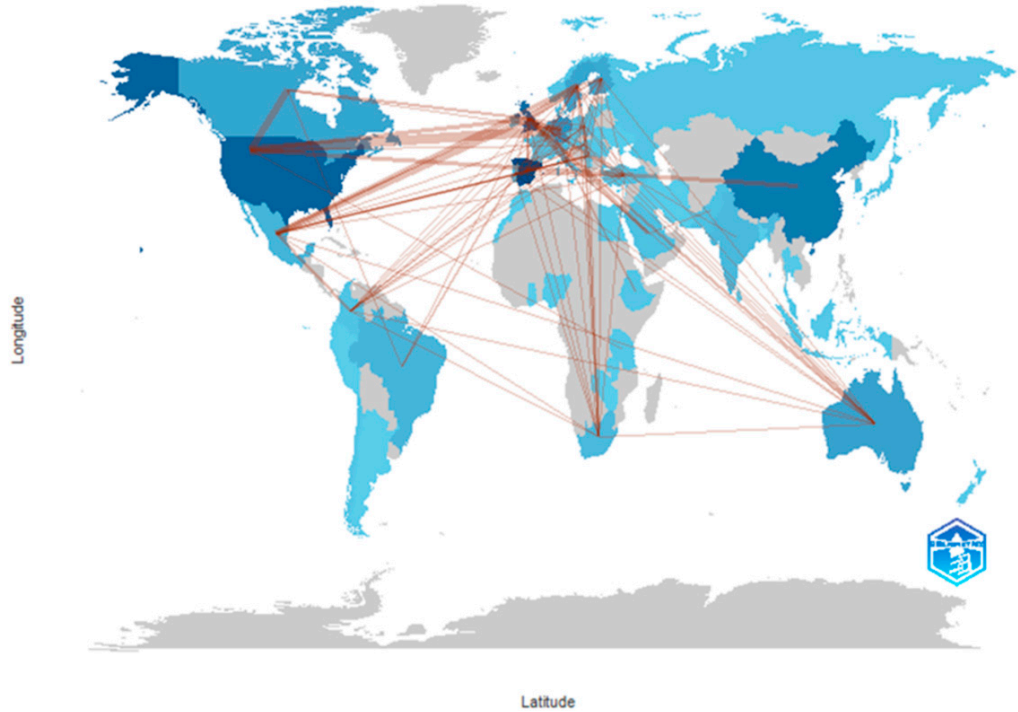


**Figure 4.** Collaboration WorldMap on sustainability competences papers in WOS. The intensity of the color is proportional to the number of publications.

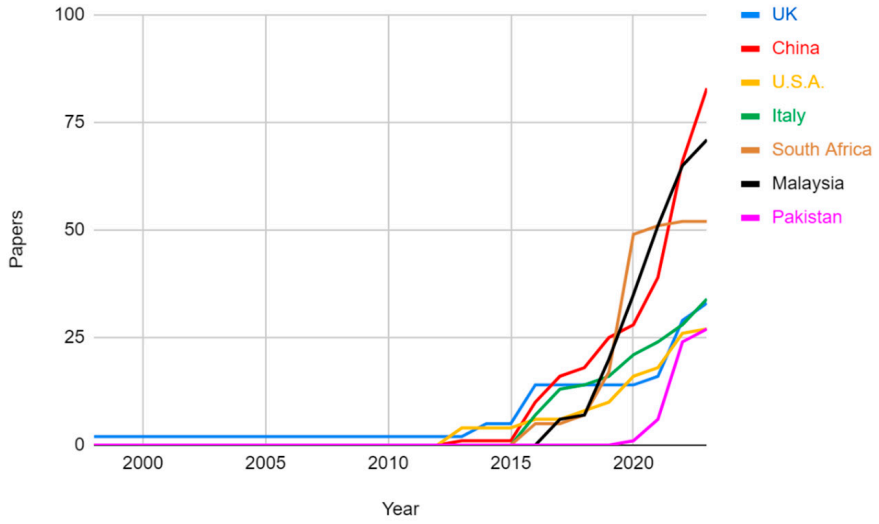


**Figure 5.** Country production over time for green skills papers in WoS.

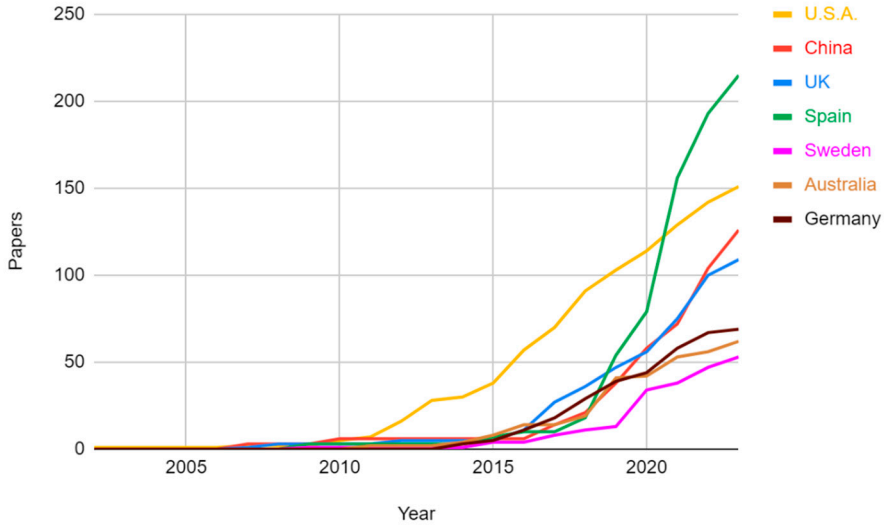


**Figure 6.** Country production over time on sustainability competences papers in WoS.

### *4.3. Research Areas and Related Trends*

Both studies on green skills and sustainability competences are transdisciplinary and therefore encompass a range of research areas. For this reason, these research fields were explored in order to understand the main areas involved in green skills and sustainability competence research. Table 1 presents the most productive field(s) in the first research topic, the relationship with other disciplines and country production for each area, based in WoS categorizations and analyses.

The most productive areas for green skills are Environmental Sciences Ecology (51 published papers, the earliest dated 2014), Business and Economics (50 published papers, the earliest dated 1998), Science Technology (31 published papers, the earliest dated 2014), Engineering (22 published papers, the earliest dated 2012), and Educational Research (16 published papers, the earliest dated 2013). Considering the annual scientific production, we noted that, except for Business and Economics, the publications in the most productive research areas are very recent. Therefore, the differences in the number of publications could be due to the more recent interest in the topic and not only to the differences between the most productive fields. In addition, it can be seen that Business and Economics and Education and Educational Research are less interdisciplinary than the others, while there are no major differences in the research areas related to the most productive countries.

**Table 1.** Subject areas in green skills topic.

| **Forecast Subject Area (No. of Papers)** | **Relation with Other Subject Areas (No. of Papers)** | **The 5 Most Productive Countries (No. of Papers)** |
|---|---|---|
| Environmental SciencesEcology (51) | Science Technology (28)<br>Business and Economics (11)<br>Engineering (6)<br>Others (4) | Malaysia (12)<br>China (11)<br>Pakistan (10)<br>South Africa (9)<br>USA (5) |
| Business and Economics (50) | Environmental Sciences Ecology (11)<br>Engineering (3)<br>Development Studies (2)<br>Others (5) | Italy (9)<br>China (7)<br>UK (6)<br>Pakistan (6)<br>Spain (6) |
| Science Technology (31) | Environmental Sciences Ecology (28)<br>Engineering (6)<br>Business Economics (1)<br>Others (2) | South Africa (10)<br>Malaysia (9)<br>China (5)<br>India, Pakistan, Taiwan, Thailand, USA (2) |
| Engineering (22) | Environmental Sciences Ecology (6)<br>Science Technology (6)<br>Computer Science, Operations Research (4, 4)<br>Others (7) | Malaysia (6)<br>Italy (3)<br>China (3)<br>India, South Africa, Spain, US (2) |
| Education and Educational Research (16) | | Malaysia (6)<br>Indonesia, China (4)<br>Australia, South Africa (2) |

Table 2 shows the most productive areas in sustainability competences, the relationship with other disciplines, and the country production for each area. The predicted subject areas are Science Technology (195 published papers, the earliest dated 2009), Environmental Sciences Ecology (158 published papers, the earliest dated 2008), Education and Educational Research (98 published papers, the earliest dated 2008), Business and Economics (52 published papers, the earliest dated 2002), and Engineering (47 published papers, the earliest dated 2007). In line with the green skills topic, we note that, except for Business and Economics, the publications in the most productive research areas are quite recent. In addition, authors in the area of Education and Educational Research seem to be more interdisciplinary when discussing sustainability competences than when talking about green skills, while in Business and Economics, authors are not interdisciplinary with regard to sustainability competences or green skills. Finally, it is interesting to note that even though the five most productive research areas are the same for both topics (Business and Economics, Education and Educational Research, Engineering, Environmental Sciences Ecology, and Science Technology), the corresponding countries differ from each other. For example, the countries that conduct more educational research on green skills are not the same countries that do more research on sustainability competences.

**Table 2.** Subject areas in sustainability competences topic.

| **Forecast Subject Area (No. of Papers)** | **Relation with Other Subject Areas (No. of Papers)** | **The 5 Most Productive Countries (No. of Papers)** |
|---|---|---|
| Science Technology (195) | Environmental Sciences Ecology (131)<br>Education Educational research (50)<br>Engineering (26)<br>Others (25) | Spain (48)<br>USA (24)<br>China (18)<br>Germany (17)<br>Sweden (17) |
| Environmental Sciences Ecology (158) | Science Technology (131)<br>Engineering (27)<br>Education Educational research (12)<br>Others (12) | Spain (39)<br>China (18)<br>Germany (16)<br>USA (15)<br>Netherlands (13) |

**Table 2.** *Cont.*

| Forecast Subject Area (No. of Papers) | Relation with Other Subject Areas (No. of Papers) | The 5 Most Productive Countries (No. of Papers) |
|---|---|---|
| Education and Educational Research (98) | Science Technology (50)<br>Environmental Sciences Ecology (12)<br>Engineering (4)<br>Others (7) | Spain (22)<br>USA (14)<br>Australia (11)<br>Finland (8)<br>Germany (7) |
| Business and Economics (52) | Public Administration (3)<br>Science Technology (3)<br>Social Sciences (3)<br>Others (9) | UK (11)<br>USA (10)<br>Brazil, Canada, Germany, China (4) |
| Engineering (47) | Environmental Sciences Ecology (27)<br>Science Technology (26)<br>Education Educational Research (4)<br>Other (18) | USA (9)<br>China (6)<br>Spain (5)<br>Canada, Denmark, Germany, Netherlands (4) |

### *4.4. Authors and the Related Co-Citation Networks*

An author and related co-citation networks analysis can be useful to compare different intellectual topic structures. We have primarily focused on co-citation networks, which are calculated when two articles are cited in a third article [65]. The network consists of nodes, the size of which is proportional to the occurrence and links which, in turn, are proportional to the co-occurrences, highlighting the strength of the links. In addition, different colors indicate an author's affiliation to a particular scientific community (see Tables A1 and A2 in the Appendix A for the details). Figures 7 and 8 show the co-citation networks for green skills and sustainability competences, where we have drawn a blue circle for authors or sources that are also represented in the other topic (see Tables A1 and A2 in the Appendix A for the complete list of authors). However, there are other authors who appear in both topics, even if they are not represented in both co-citation networks. For instance, Presha Ramsarup, Eureta Rosenberg, Khan Syed, and Heila Lotz-Sisitika are prolific authors on the topic of green skills, but only have one publication on the other topic, and the number of publications is not relevant. In addition, we found that the top ten authors in these topics with a higher relevance index (between 10 and 3 h- and g-indexes and between 2 and 0.6 m-indexes) do not have a single publication in the other topic.

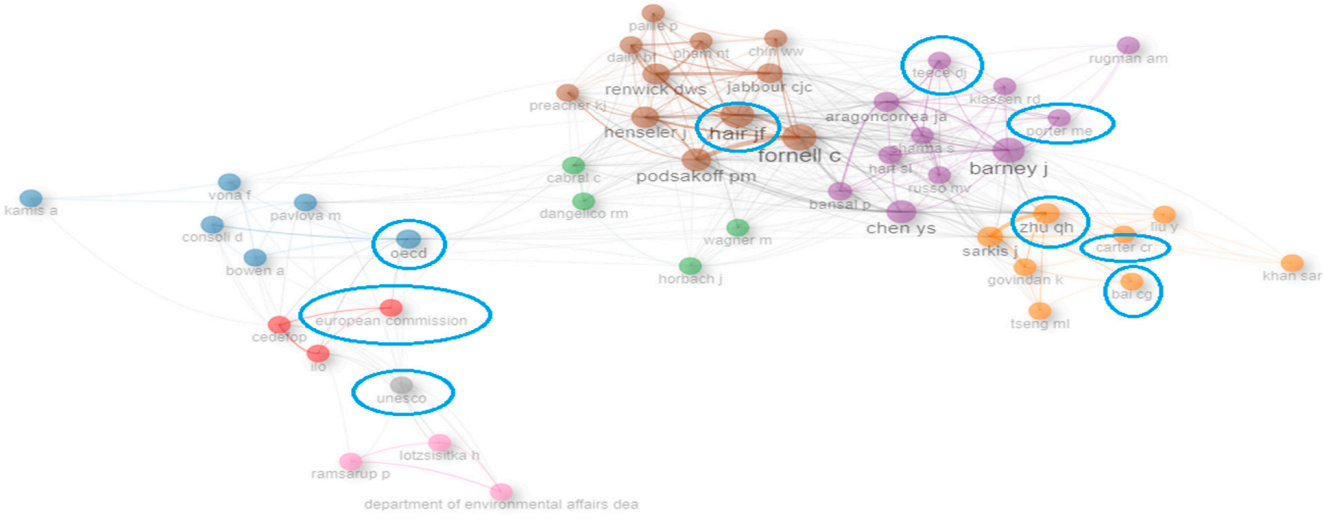


**Figure 7.** Co-citation networks on green skills authors in WoS. Blue circles identify authors or sources that are also found in the sustainability competences topic and different colors indicate an author's affiliation to a particular scientific community.

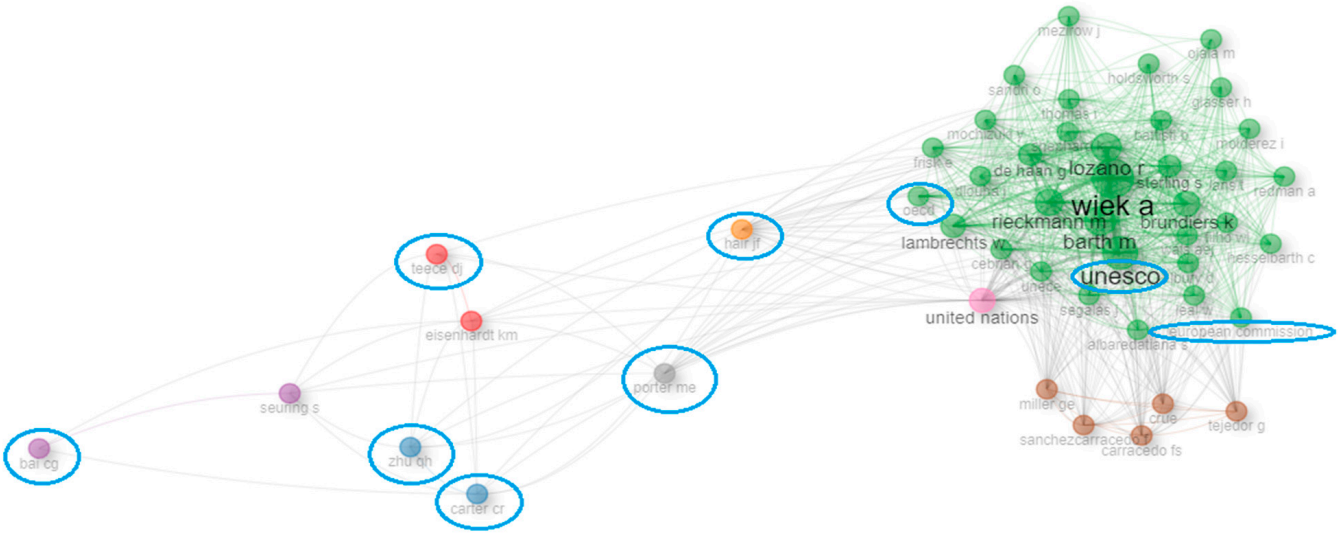


**Figure 8.** Co-citation networks on sustainability competence authors in WoS. Blue circles identify authors or sources that are also found in the green skills topic and different colors indicate an author's affiliation to a particular scientific community.

### *4.5. Keywords and Thematic Map*

Keyword analysis makes it possible to understand the conceptual structure of a framework, which is useful for reflecting on the boundaries of the research. Clearly, the keywords used in the query also emerged among the most frequent keywords and themes in the results. Tables 3 and 4 show the most popular keywords in the two different topics. It is also interesting to observe the differences between the keywords chosen by the authors and Keywords Plus. For instance, authors include "sustainable development" among the most relevant keywords, while it is less frequently used in the list of terms extracted by Keywords Plus, which often appear in the titles of an article's references and not necessarily in the title of the article or as author keywords. According to Zhang et al. [61], we can observe that author keywords refer more to the article's topics, while Keywords Plus refers more to the research methods, areas, and backgrounds. In Table 3, the most common Keywords Plus are performance, impact- and resource-based view, management, and sustainability, followed by innovation, companies, supply chain management, and finally, education, environmental management, and human resource management. In the column of keywords chosen by the authors, the most common words are green skills, sustainability, and green, followed by environment, green competences and capabilities, green human resource management, green jobs, and performance. This is followed by green economy, green innovation, and sustainable development, and finally, education, environmental sustainability, green building, and green training. The most frequently occurring Keywords Plus in relation to sustainability competences in Table 4 are key competences, higher education, education, competences, and management, such as university, knowledge, performance, and science, followed by students, impact, curriculum, and finally, future, innovation, and sustainability. Authors mainly chose terms such as sustainability, sustainability competences, ESD, competences, higher education, and sustainable development, followed by education for sustainability, education, development, and finally, assessment, learning, and systems thinking.

Finally, we conducted a thematic analysis combining the performance analysis and science mapping to show the main theme of the topics in a special diagram delineating the fundamental and driving topics on the right and the niche and emerging or declining themes on the left, based on the authors' keywords due to the better quality of these data in the WoS database [59]. Each keyword is assigned to only one topic, which is represented in a cluster with different colors (Figures 9 and 10). For the green skills topic, the driving themes are mainly "green" and "green skills", followed by "green human resource management" and "environmental sustainability", and then by "eco-innovation" and "sustainable".

The basic issues that have proven to be fundamental to this topic are decent work and, more recently, climate change. Only one niche theme emerges in the diagrams, namely green procurement practices, while the emerging themes associated with the green skills topic are small and medium enterprises and sustainable development. On the topic of sustainability competences, the driving themes are mainly sustainability competences and sustainability education, followed by university, engineering education, sustainability, learning outcomes, entrepreneurial resilience, and, more specifically, corporate social responsibility (CSR), decision making, and, more recently, management. The fundamental themes in the sustainability competences topic are problem- and project-based learning (PBL and PjBL), sustainable development goals, environmental sustainability, experiential learning, innovation, and, more recently, blended learning. The more specific themes are entrepreneurship, teachers, and employability. Finally, the new themes are cognitive skills, community development, information technology, and analysis.

**Table 3.** Keywords frequency in green skills topic.

| Keywords Plus (Occurrence) | Author Keywords (Occurrence) |
| --- | --- |
| Performance (33) | Green skills [1] (27) |
| Impact (20)—resource-based view (20)—Management (18) | Sustainability/sustainable (18)<br>Green [1] (16) |
| Sustainability/sustainable (15) | Environment/environmental (11)<br>Green competences [1] (11) |
| Innovation (12) | Green capabilities [1] (10) |
| Companies (11) | Green human resource management (6)—Green jobs (6)—Performance (6) |
| Supply chain management (10) | Green economy (5)—Green innovation (5)—Sustainable development (5) |
| Education (9)—Environmental management (9)—Human resource management (9 HRM) | Education (4)—Environmental sustainability (4)<br>Green building (4)—Green training (4) |

[1] Words in the set of terms used to create the query.

**Table 4.** Keywords frequency in the sustainability competence topic.

| Keywords Plus (Occurrence) | Author Keywords (Occurrence) |
| --- | --- |
| Key competences (79) | Sustainability/sustainable [1] (124) |
| Higher education (56) | Sustainability competences [1] (72) |
| Education (44) | Education for sustainable development/ESD (52) |
| Competences (29)—Management (29) | Competences [1]/capabilities [1] (51) |
| University (28) | Higher education (50) |
| Knowledge (26) | Sustainable development (41) |
| Performance (25)—Science (25) | Education for sustainability/sustainability education/education for sustainable (39) |
| Students (20) | Education (30) |
| Impact (18) | Development (20) |
| Curriculum (17) | Assessment (13) |
| Future (16)—Innovation (16)—Sustainability (16) | Learning (9)—Systems thinking (9) |

[1] Words in the set of terms used to create the query.

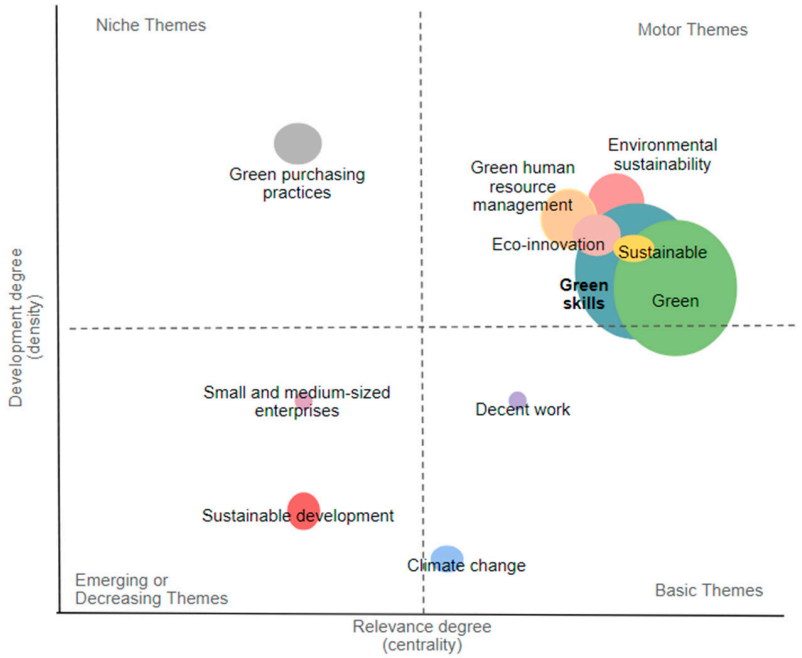


**Figure 9.** Thematic map on green skills. Each keyword is assigned to only one topic, which is represented in a cluster with different colors.

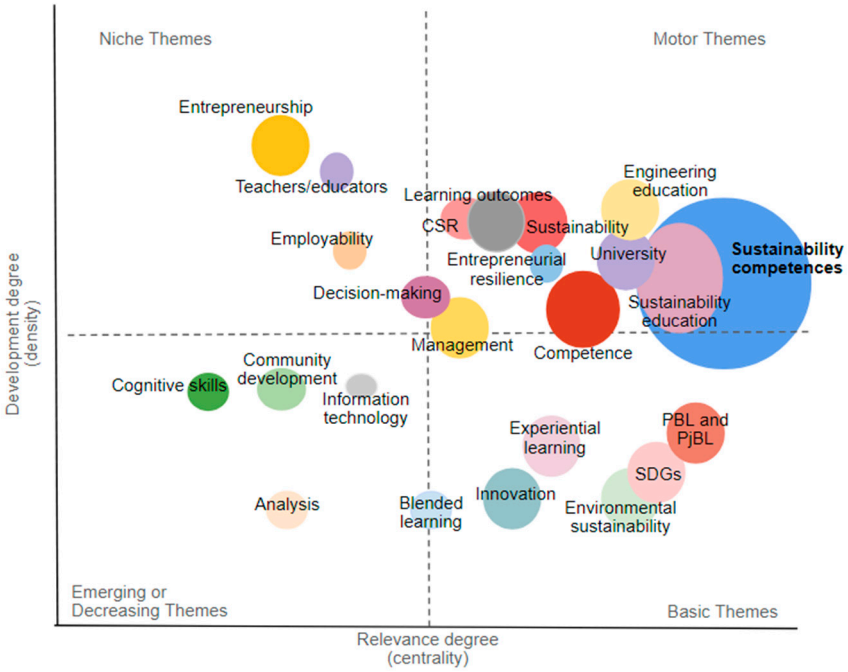


**Figure 10.** Thematic map on sustainability competences. Each keyword is assigned to only one topic, which is represented in a cluster with different colors. The acronym CSR stands for Corporate Social Responsibility; SDGs for Sustainable Development Goals; PBL and PJBL for problem-based learning and problem-based project learning.

## 5. Discussion

In line with the first research question posed at the beginning of this paper, we examined the annual scientific production, the most productive countries, the associated collaboration networks and the countries' production over time, the research areas and their associated trends, the authors and their associated co-citation networks, and the thematic map of "green skills" and "sustainability competences", in order to support the dialogue

between the different disciplines dealing with these two apparently similar topics in the field of sustainability.

Concerning the annual scientific production, the interest in the two topics of our study—green skills and sustainability competences—is quite recent, in line with the similarly recent interest of institutions in sustainability and sustainable development [16,37]. The topic of green skills appeared slightly earlier than sustainability competences, in the 1990s, after the United Nations Conference on Environment and Development in Rio de Janeiro and the establishment of the World Business Council for Sustainable Development (WBCSD), a platform of enterprises developed in 1995 to respond to the sustainability challenges that were gradually entering the corporate sphere. Subsequently, publications on this topic resumed in 2007, in line with the increase in publications on sustainability competences, even though the first articles on this other topic had already appeared in 2002, probably because ESD strategies began to be outlined internationally from the 2000s [66–69]. Sustainability competences seem to have gained importance in 2007, following the executive summary of the OECD program "Definition and Selection of Competencies" [70], and later, the "Recommendation of The European Parliament on Key Competencies" [71]. Green skills seem to have gained importance in 2012, following an increasing number of research studies on green jobs since 2009 (probably due to the Copenhagen Climate Agreement of the same year, which did not contain mandatory obligations but invited countries to specify emission reduction targets and corresponding actions to limit the increase in emissions). Moreover, at the 2012 Rio Conference, article 154 on green jobs and related skills stated: "We acknowledge the importance of efforts to promote job creation, including green jobs initiatives and related skills" ([72], pp. 29). Both topics increased significantly in 2015–2016, following the 2030 Agenda for Sustainable Development, which mentions neither green skills nor sustainability competences but promotes sustainable development education. Interest in these topics is growing, underlined by the inflection points of 2020 and 2022 for green skills and 2019 and 2021 for sustainability competences, probably due to global crises, such as the pandemic in 2020 and subsequent economic crises, climate change, and extreme environmental events that became more frequent from 2019 onwards [5,73].

Despite the similarity in the development of these two themes due to the international events they might be linked to, an analysis of the scientific production of the countries shows some differences. Given that higher scientific production could depend on the productivity of the research areas and the higher population size of some countries, such as China and the US, or on the policies of countries that are more aligned with the standards of the WoS database, one of the most surprising results is the difference between the greater orientation towards green skills in developing countries than in the Western ones. Indeed, sustainability competences seem to be studied more in Europe and the Americas, and more cross-country studies are conducted. This is also evident from the report by Redman et al. which states that publications related to sustainability competence assessments have taken place almost exclusively in OECD countries [42]. For instance, Spain does not appear in the top five countries involved in green skills studies, yet ranks first in respect of sustainability competences. The country's production therefore seems not to depend on a higher population size or orientation towards WoS standards, though it may be due to specific state incentives on a topic as well as the presence of research centers in Spain, such as the European Commission's Joint Research Centre (JRC). The reason why industrialized countries pay more attention to sustainability topics could be due to the United Nations' guidelines focused on all dimensions of sustainability and not exclusively on the environmental ones, while developing countries pay less attention to social dimension due to their urgent need to achieve high levels of growth in line with recent international environmental regulations. According to the results of country-specific production over time, the US and the UK show similar trends for green skills, while the Chinese, Italian, South African, and Malaysian studies emerged more significantly in 2015, the same year of the 2030 Agenda, even though its focus is on sustainable development and not only on the environmental dimension of sustainability. In contrast, Pakistani studies

appear to be even more recent, possibly due to the recent environmental disasters that have affected the country. In terms of sustainability findings, in the US, reflections on sustainability competences were contemporaneous with the discussion on green skills, in contrast to the UK publications. On this topic, the American publications appeared earlier than in the other countries, perhaps due to the deliberations on ESD [66,67], while the other publications appeared well after the 2030 Agenda, with the largest increase in the last five years. These results highlight that, given the number of publications, there is a greater focus on sustainability competences than on green skills, although both are increasing. In addition, they appear to be closely related to the SDGs of the 2030 Agenda.

The research areas are similar for both topics, and for both, most of the interdisciplinary fields are Environmental Sciences, Engineering, and Science Technology. It is useful to observe that green skills tend to be studied more in the fields of Environmental Sciences, Business, and Economics. In contrast, education tends to use the term "sustainability" rather than "green". The productivity of each country in each research area is quite different, which may mean that the data is not as strongly influenced by greater interest or specialization in disciplines depending on the country. In European countries, there are more educational studies that look at sustainability competences rather than green skills. In contrast, Australian educational studies address both topics, perhaps due to environmental disasters in the country and the need to provide education with a complex perspective to counter these, while Chinese educational studies are less focused on green skills. UK publications are higher in Business and Economics, which could depend on the relatively strong economic culture. In particular, in terms of sustainability competences, the most surprising result is the first position of Spain, which appears in all of the five most relevant research areas except for Business and Economics. Developing countries seem to investigate green skills more than sustainability competences; in fact, only China and Brazil appear in Table 2 in respect of sustainability competences.

It is interesting to note that both topics have been used in the international documents of the United Nations and the European Commission, which is evident from the co-citation networks (Figures 7 and 8 and in the Appendix A). This could be the reason why sustainability competences and green skills are often considered synonymous terms. However, when analyzing the results of the intellectual structure of the two topics, it becomes clear that there are few common nodes. In addition, we found that authors who have published on one of the two topics do not have a relevant number of publications on the other topic. Therefore, we can postulate that the two topics are developed in quite different research networks. Figure 8 shows that the authors who share the green skills topic occupy a marginal position. Those in the bottom left-hand corner belong to the same scientific community that deals with green skills, and according to the research interests of these authors, they are involved mainly in the field of green supply-chain management, which can be found in orange in the green skills topic (Figure 7 and in the Appendix A). According to the research interests of the scholars, the common authors in the middle are engaged in development studies related to ecology, mainly in the organizational field (in purple, Figure 7 and in the Appendix A). Finally, Hair Joseph F. belongs to the business field and it appears related to green human resource management (in brown and green, Figure 7 and in the Appendix A). On the other hand, in the field of sustainability, the largest scientific community deals with ESD (in green, Figure 8 and in the Appendix A), whereas there are few publications related to green jobs and not relevant to the intellectual structure, unlike the topic of green skills (in blue and pink, Figure 8 and in the Appendix A).

Finally, if we look at the keywords chosen by the authors, we can see that the contents of the conceptual structures of the two topics are quite similar, as keywords such as "sustainability" and "education" appear in both of them. However, from the authors' keywords, which are more related to the object of research [61], we can conclude that green skills have more to do with environmental aspects than the other topic. According to Keywords Plus, on the other hand, their background is linked to an economic culture based on performance, impact, management, and innovation, even though the Keywords

Plus data in green skills are poor due to the low number of documents in this area, unlike sustainable issues, for which they are acceptable. Sustainability competences also seem to be related to a performance culture, but are more related to key competences rather than to the environment. Indeed, on the second topic, according to Redman et al. [42], the results focus on education and higher education, which are useful for guiding people towards future and alternative life paths, rather than green jobs in particular. These results are also confirmed via the thematic maps (Figures 9 and 10). In fact, green skills are strongly linked to environmental sustainability, such as climate change, although green jobs do not appear, while decent work is one of the fundamental themes. In addition, education is part of green human resource management, with a greater focus on the entrepreneurial sphere—studies on SMEs are included in the recent documents dated between 2021 and 2022. It is also interesting to note that among the emerging topics concerning green skills, the theme of sustainable development appears from 2021 onwards. From the thematic map on sustainability competences, it appears that this topic is based on environmental sustainability, similar to the other topic and in line with Redman et al. [42], yet it is also linked to the social and economic dimensions of sustainability, such as CSR, entrepreneurial resilience, and community development, which are among the emerging themes. In addition, sustainability competences have a stronger link to education, whether in sustainability or engineering, with specific educational approaches such as experiential learning, problem-based learning (PBL) and problem-oriented project learning (PjBL), and blended learning being among the emerging themes.

By delineating the similarities and differences between these two topics, it becomes evident that green skills and sustainability competences are both emerging topics in different disciplines, studied via different scientific networks depending on the country and author. For this reason, it is necessary to outline a preliminary definition that distinguishes them from each other, in order to provide more clarity and guide future research. To answer the second research question, we looked at the results that emerged from the quantitative analysis of the conceptual dimension of these two topics, based on a comparison of the keywords—including Keywords Plus—and the thematic analysis. While green skills are mainly related to the environment, sustainability competences are more transversal, in line with the multidimensionality of sustainability. Therefore, we can provisionally define them respectively as technical-scientific skills related to the development of green jobs and as transversal competences that promote all dimensions of sustainability.

## 6. Conclusions

Research on green skills and sustainability competences has gained prominence in recent years, probably due to pressure from top–down international policies as well as bottom–up social movements to find and promote alternative development paths to human wellbeing [74,75]. This article presents a scoping review of green skills and sustainability competences using sociometric analyses with the aim of providing guidance for researchers, trainers, and social planners from different disciplines interested in clarifying this field and in conducting transdisciplinary activities. Specifically, more than 500 papers in the WoS database from the years 1998–2023 were analyzed. At first glance, the two topics seem to correspond to each other; for instance, by the annual scientific production, search areas, and keywords used by authors. Yet the opposite proved to be true: there are major differences between research networks, which tend to deal with one topic rather than the other. As previously mentioned, a comparison of the results shows that more dialogue between the disciplines is needed to define the skills and competences required for education for sustainability. In conceptual frameworks, green skills are primarily related to the environment and could therefore be defined as technical–scientific skills related to the development of green jobs, without forgetting the impact they have on other dimensions for a just and inclusive transition [37]. In line with the integrated dimensions of the second topic, sustainability competences can be defined as the key competences that promote all dimensions of sustainability, that is, competences useful for holistic human development [44].

Both topics are essential: green skills to create the green jobs needed to address today's environmental catastrophes and climate change; sustainability competences to manage the transition to sustainable development and enable a paradigm shift based on holistic human development. The latter are fundamental for developing intrapersonal competences to increase eco-system awareness, interpersonal competences to foster the cooperation needed to address global stewardship problems, systemic thinking for integrated problem-solving in complex adaptive systems [18], and anticipatory- and action-oriented competences to cope with unpredictable future scenarios and shape new ones. For these reasons, it is important to integrate them and conduct transdisciplinarity research when talking about sustainability in a competence-based society. Moreover, it is important to show this distinction in order to maintain the complexity of the concept of sustainability, which is necessarily linked to a green transition, but should not be limited to this dimension alone. The distinction between these two definitions is useful in highlighting the importance of the meaning of decent work in studies on future jobs and green jobs [76] in both industrialized and developing countries to enable a green transition that is both inclusive and socially sustainable [37]. A comparison of the results shows that the two theoretical frameworks are different. However, both are necessary for sustainability, suggesting the need for more dialogue between the disciplines working on defining these competences. Finally, in this scoping review, we found that the keyword "performance" occurs more frequently than "sustainability", indicating an implicit connection with performance culture in both topics, which is consistent with a neoliberal behaviorist perspective on competences [37]. This shows that there is a danger that more attention is paid to economic growth than to sustainable development in the sense of holistic wellbeing.

*Limitations and Future Research*

This research is a scoping review and can therefore inform policy-makers and researchers for future developments, even though its findings are not in-depth. For this reason, future systematic or qualitative reviews could be added to provide a deeper understanding of these topics and to assess which papers are more relevant for defining the patterns linking green skills and sustainability competences [34]. In addition, the use of sociometric analyses does not take into account the qualitative dimensions of the selected papers. However, our method was useful in showing the "big picture" of extant research and highlighting differences and similarities between the two topics.

Our study could contribute to future research, including more systematic and theoretically orientated reviews, to clarify the definition of green skills and sustainability competences despite the limited number of documents in the database used. For this reason, it could be interesting in future studies to integrate other databases and case studies to compare and further explore the differences between countries, as well as the non-reviewed and grey literature. Moreover, the terminology related to competences is complex; for instance, scholars might focus on only one aspect of skills and competences, such as the abilities, attitudes, and values related to sustainability, without considering the global view of competences [16,17]. For this reason, it would be possible to include other keywords in the analysis; for example, for the other meanings of sustainability, such as sustainable development and ecological transition. Finally, qualitative reviews and field studies are also needed, since they could contribute to a deeper understanding of these topics and promote the idea that both concepts are necessary to achieve sustainability.

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**Data Availability Statement:** The data presented in this study are available on request from the corresponding authors.

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**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix A

**Table A1.** Co-citation networks on green skills (Figure 7).

| Cluster | Node | Betweenness | Closeness | PageRank |
|---|---|---|---|---|
| European frameworks (red colour) | European Commission | 0.45209 | 0.010989 | 0.014757 |
| | ILO | 2.579877 | 0.011364 | 0.017561 |
| | CEDEFOP | 3.152442 | 0.011364 | 0.019444 |
| Policy development (blue colour) | OECD | 14.64649 | 0.011905 | 0.021461 |
| | Pavlova Margarita | 5.976175 | 0.011364 | 0.015307 |
| | Kamis Arasinah | 0 | 0.010101 | 0.007478 |
| | Vona Francesco | 1.207098 | 0.010753 | 0.013268 |
| | Bowen A. | 2.000223 | 0.010753 | 0.01471 |
| | Consoli Davide | 0.070074 | 0.010638 | 0.014433 |
| Green human resource management (green colour) | Cabral Clement | 6.417114 | 0.011628 | 0.014713 |
| | Horbach Jens | 1.495119 | 0.01087 | 0.010016 |
| | Wagner Marcus | 4.290813 | 0.011905 | 0.012626 |
| | Dangelico Rosa Maria | 2.425777 | 0.011111 | 0.012678 |
| Ecology and the organizational field (purple colour) | Chen Yu-Shan | 29.36289 | 0.012821 | 0.023475 |
| | Aragon-Correa, J. Alberto | 7.214644 | 0.012048 | 0.029957 |
| | Barney Jacob | 63.4283 | 0.012987 | 0.036189 |
| | Bansal Pratima | 13.74247 | 0.012987 | 0.022704 |
| | Porter Michael E. | 0.807757 | 0.010989 | 0.021953 |
| | Hart Stuart L. | 4.615243 | 0.012346 | 0.021685 |
| | Rugman Alan M. | 0 | 0.01 | 0.010644 |
| | Teece David J. | 2.307526 | 0.011765 | 0.024221 |
| | Sharma Sanjay | 4.105142 | 0.012048 | 0.024399 |
| | Russo Michael V. | 4.358181 | 0.012048 | 0.022932 |
| | Klassen Robert D. | 4.064496 | 0.012048 | 0.020946 |
| Green supply-chain management (orange colour) | Zhu Qinghua | 3.640561 | 0.0125 | 0.028999 |
| | Sarkis Joseph | 3.444173 | 0.012821 | 0.029055 |
| | Khan Syed Abdul Rehman | 0 | 0.008065 | 0.008188 |
| | Bai Chunguang April | 0.040972 | 0.010753 | 0.014665 |
| | Govindan Kannan | 0.442517 | 0.011494 | 0.017591 |
| | Tseng Ming-Lang | 0.023664 | 0.010753 | 0.011268 |
| | Carter Craig R. | 0.179848 | 0.011236 | 0.015118 |
| | Liu Yanping | 0.104285 | 0.011236 | 0.013376 |
| Green human resource management (brown colour) | Chiappetta Jabbour, Charbel Jose | 7.890027 | 0.012346 | 0.026328 |
| | Hair Joseph F. | 18.81113 | 0.013333 | 0.035545 |
| | Fornell Claes | 26.01581 | 0.013333 | 0.03626 |
| | Henseler Jorg | 11.04747 | 0.012987 | 0.030575 |
| | Renwick Douglas W. S. | 8.095059 | 0.012048 | 0.031115 |
| | Podsakoff Philip | 13.68607 | 0.012987 | 0.029599 |
| | Daily Bonnie F. | 0.553495 | 0.010989 | 0.02333 |
| | Pham Nat Than | 0.712652 | 0.011364 | 0.023563 |
| | Chin Wynne | 1.591914 | 0.011905 | 0.021676 |
| | Preacher Kristopher J. | 1.660371 | 0.011628 | 0.017357 |
| | Paille Pascal | 0 | 0.01 | 0.01831 |

**Table A1.** *Cont.*

| Cluster | Node | Betweenness | Closeness | PageRank |
|---|---|---|---|---|
| Environmental education (pink colour) | Lotz-Sisitka Heila | 0.068571 | 0.010309 | 0.016663 |
| | Presha Ramsarup | 0 | 0.010204 | 0.016138 |
| | Department of Environmental Affairs | 0.022857 | 0.010309 | 0.016475 |
| International institution (grey colour) | UNESCO | 2.410416 | 0.011364 | 0.007974 |

**Table A2.** Co-citation networks on sustainability competences (Figure 8).

| Cluster | Node | Betweenness | Closeness | PageRank |
|---|---|---|---|---|
| Organizational field (red colour) | Teece David J. | 0.046927 | 0.010989 | 0.009486 |
| | Eisenhardt Kathleen M. | 0.515603 | 0.011364 | 0.009966 |
| Green supply-chain management (blue colour) | Carter Craig R. | 2.134349 | 0.011236 | 0.010221 |
| | Zhu Qinghua | 0.657205 | 0.011111 | 0.009468 |
| ESD (green colour) | UNESCO | 3.791784 | 0.011236 | 0.055239 |
| | Wiek Arnim | 3.555992 | 0.011364 | 0.071066 |
| | Lozano Rodrigo | 4.988956 | 0.011765 | 0.048482 |
| | Barth Matthias | 0.947353 | 0.011236 | 0.050267 |
| | Brundiers Katja | 0.38396 | 0.011236 | 0.039894 |
| | Rieckmann Marco | 0.487874 | 0.011111 | 0.044752 |
| | Lambrechts Wim | 0.548215 | 0.011236 | 0.037138 |
| | Sterling Stephen | 0.24113 | 0.011111 | 0.033431 |
| | De Haan Gerhard | 0.305318 | 0.011111 | 0.032806 |
| | Wals Arjen E. J. | 0.544371 | 0.011364 | 0.027378 |
| | Segalas Jordi | 1.074754 | 0.011111 | 0.026512 |
| | Cebrian Gisela | 0.428797 | 0.010989 | 0.02462 |
| | Tilbury Daniella | 0.327552 | 0.010989 | 0.023223 |
| | OECD | 0.082907 | 0.01087 | 0.015948 |
| | Shephard Kerry | 0.106432 | 0.010989 | 0.023216 |
| | Walter Leal Filho | 0.347622 | 0.011111 | 0.017486 |
| | Thomas Ian | 0.263384 | 0.011111 | 0.022281 |
| | Battisti Bryce T. | 0.070679 | 0.010753 | 0.024321 |
| | Albareda-Tiana Sílvia | 0.304646 | 0.010989 | 0.015968 |
| | Redman Aaron | 0.006018 | 0.010638 | 0.017251 |
| | UNECE | 0.17716 | 0.010989 | 0.01786 |
| | Frisk E. | 0.036867 | 0.010638 | 0.01488 |
| | Ojala Maria | 0 | 0.010417 | 0.009116 |
| | Hesselbarth Charlotte | 0.080535 | 0.010989 | 0.015378 |
| | Mezirow Jack | 0 | 0.010417 | 0.008807 |
| | European Commission | 0.126158 | 0.010989 | 0.009723 |
| | Lans Thomas | 0.158683 | 0.011111 | 0.016767 |
| | Mochizuki Yoko | 0.039166 | 0.01087 | 0.017044 |
| | Glasser Harold | 0 | 0.010417 | 0.012059 |
| | Molderez Ingrid | 0.004396 | 0.010638 | 0.011697 |
| | Sandri Orana | 0.02052 | 0.010638 | 0.011955 |
| | Dlouha Jana | 0 | 0.010417 | 0.012955 |
| | Holdsworth Sarah | 0 | 0.010417 | 0.011429 |
| Green supply-chain management (purple colour) | Seuring Stefan | 0.230305 | 0.010989 | 0.007849 |
| | Bai Chunguang April | 0 | 0.010526 | 0.004858 |
| Green human resource management (orange colour) | Hair Joseph F. | 2.107599 | 0.013158 | 0.005534 |

**Table A2.** *Cont.*

| Cluster | Node | Betweenness | Closeness | PageRank |
|---|---|---|---|---|
| Engineering education (brown colour) | Sánchez-Carracedo, Fermín | 7.460519 | 0.013889 | 0.010924 |
| | Tejedor Gemma | 5.15403 | 0.013514 | 0.008408 |
| | Conference of Rectors of Spanish Universities (CRUE) | 6.626726 | 0.013889 | 0.01101 |
| | Miller Gloria E. | 10.68824 | 0.013889 | 0.010717 |
| International institution (pink colour) | United Nations | 194.3014 | 0.019608 | 0.013116 |
| Economic development and organizational field (grey colour) | Porter Michel E. | 1.245206 | 0.0125 | 0.005826 |

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