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State of the Research on Teacher Education and Sustainability: A Bibliometrics Analysis

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Abstract

Qualitative education is one of the key contributors in achieving the goal of sustainability. Several studies mention that the sustainability curriculum and educators can play an immense role in developing awareness in practicing the concept of sustainability. Relatively there is no comprehensive study to typify the recent contributions of teacher education for sustainability. In this light, the aim of the study is to understand the progress of the research on teacher education for sustainability (TES) in terms of growth, evolution, influence and significant research themes. To achieve the aim of the study, 1782 documents indexed in the Scopus database over three decades starting from 1991 to 2020 were analyzed by using bibliometric analysis. The data are visualized in the paper by using VOSviewer and Tableau. Results show that there has been a significant increase in yearly publications and citations over the years, trending research papers, productive authors, institutions and countries and thematic areas of research. Most frequently published journal has a considerable cite score and quartile. Universities from Australia published the most. The most commonly published themes are education for sustainability, Agenda 21, sustainable development education, environmental education, and later the focus is shifted to teacher training, teachers, education, values, teaching and education policy, sustainability competencies. Future research should focus on blended learning, digital learning, other modern tools and techniques to achieve the goal of sustainable development as well as to address the issue of teaching sustainability during uncertainty conditions.

Keywords: bibliometrics, research progress, sustainability, teacher education, uncertainty

Background

The future of the sustainable development depends on how we perceive the concept (Kahriman-Ozturk et al., 2012; Hopkins & McKeown, 2002). The major challenge lies in its practice, which requires ethical, moral, attitudinal and behavioral changes and awareness of motivation particularly under uncertainty conditions (Steinemann, 2003; Rozentale et al., 2021; Salīte et al., 2021). In this regard, education plays a vital role in changing these aspects, including the reorientation of education for sustainable development (Selby, 2006). Studies acknowledge that the awareness and education are of primary importance in achieving sustainable development (Murphy, 2012; Hopkins & McKeown, 2002). More precisely, researchers consider that teacher education and awareness (Alam, 2013; Hopkins & McKeown, 2002), consideration and effective implementation of sustainability curriculum (Barth & Rieckmann, 2012; Rieckmann, 2012), developing the awareness and producing the sustainable human resources (Kahriman-Ozturk et al., 2012; Rieckmann, 2012) are crucial factors to achieve sustainable development. For instance, the study by Fien et al. (2002) demonstrated that the effective integration of sustainability curriculum and teacher influence on students towards environmental education contributed to adopting sustainable lifestyle.

The concept was first discussed in the Brundtland report, also called "Our Common Future", of the World Commission on Environment and Development in 1983 (The Brundtland Report, 1987). Initially, the term "environmental education" was used widely for sustainability education. Further, it was well discussed in "Chapter 36 of Agenda 21", which was adopted during the United Nations Conference on Environment and Development held in Rio de Janeiro (Global Forum at Rio de Janeiro, 1992). Agenda 21 insisted on the thrust areas in education for sustainability, including availability of basic education, reorienting the curriculum towards sustainability, awareness and training (Gadotti, 2009). UNESCO declared the decade from 2005 to 2014 as the UN Decade of Education for Sustainable Development (ESD), with the aim of addressing the socio-economic and environmental problems through education and learning (UNESCO, 2005, paragraph 4). There has been an immense importance on reorienting teacher education for sustainable development. The idea behind this strategy is to encourage students to critically think and examine the issues and deal with simple solutions and by realizing them to take a leadership role in their professional career (UNESCO, 2005; Smith, 2011). ESD was given more importance compared to the social and economic dimensions of sustainability, as previously environmental sustainability was the priority area. The importance of ESD was reemphasized to achieve Millennium Development Goals (MDGs), and the goal number two was dedicated to obtain primary education. It is criticized that the ESD is left in ambiguity to achieve sustainable development. Several studies explored the MDGs and the difficulty of achieving broader goals. Further, the concept of Sustainable Development Goals (SDGs) was introduced ambitiously to achieve SDGs by 2030 (Kopnina, 2020). In this regard, "Education 2030: Towards Inclusive and Equitable Quality Education and Lifelong Learning for All" was adopted during the World Education Forum in Incheon, the Republic of Korea, in 2015 with the aim of highlighting the role of education as a driver for the achievement of SDGs (Kioupi & Voulvoulis, 2019). Several initiatives were made to implement education for sustainability at the university and country levels, for instance, "Teaching for a Sustainable World", "Learning for a Sustainable Environment – Innovations in Teacher Education Project" (Fien & Maclean, 2000).

It is widely understood that the concept of sustainable development plays a significant role in overcoming socioeconomic challenges of the world, including consequences of COVID-19. Education for sustainability is one of the key contributors in achieving the goal of sustainability. United Nations declared the period from 2005 to 2015 as a decade of sustainability, and education is recognised as key component to achieve it (Leal Filho et al., 2015). It is well understood that teacher education plays an immense role in educating the future generation and developing awareness to achieve the agenda of sustainable development. It is argued that the TES is a relatively young field of study that is still evolving (Cochran-Smith & Zeichner, 2006). Sustainable development is a long-term process that requires continuous efforts and strategies. To achieve the agenda of 2030, it is crucial to analyze the state of research in the context of ESD (Phuong Thao et al., 2019).

Bibliometric Analysis of Teacher Education for Sustainability

Several studies focused on the research progress of education for sustainable development. For example, Pipere et al. (2015) examined the research output of the members of the Baltic and Black Sea Circle Consortium on Educational Research (BBCC) on the occasion of 10th anniversary by using the bibliometric study to know the qualitative and quantitative research progress and change over the years. The same anniversary also coincided with the UN Decade of ESD. Avelar et al. (2019) applied bibliometric analysis to find out research on advancing SDGs by using the Web of Science database. Results showed that management, ecology, environmental studies, and environmental sciences were the major themes. Characteristics, trends and growth were the most preferred areas of the ESD research (Côrtes & Rodrigues, 2016; Reunamo & Pipere, 2011).

Various studies applied bibliometric tools in relation with ESD, for instance, trends in the moral education in terms of the most cited articles and journals, themes from 2010 to 2019 (Julia et al., 2020), scientific production of science teacher education in Turkey from 2005 to 2014, higher education for sustainability (Gavioli & Mourão, 2019; Cullen, 2017; Hallinger & Chatpinyakoop, 2019; Alejandro-Cruz et al., 2019), education and behavior towards low carbon (Hudha et al., 2020). In the context of ESD, researchers also addressed such issues as ESD knowledge production in K-12 schools (Hallinger & Nguyen, 2020), initial teacher education for the inclusive education (Cretu & Morandau, 2020), quality education in the context of Agenda 2030 (González García et al., 2020), evolution of education for sustainable development from 1992 to 2018 (Grosseck et al., 2019). Goller and Rieckman (2022) carried out a systematic literature review on understanding teacher educators' perceptions of ESD based on a bibliographic method. They identified only 12 papers during the period of 1992–2021. The study concluded with the statement that future education with institutional support would be needed (Goller & Rieckman, 2022). Other study pointed out that during the COVID-19 pandemic motivation as a tool for career development and education was around only 50 % in the education sector (Rozentale et al., 2021).

To the best of the authors' knowledge there are no studies to examine the growth, influence and impact of research on teacher education for sustainability. Numerous studies mention that the sustainability curriculum and educators can play an immense and crucial role in developing awareness and practicing the concept of sustainability

through curriculum, teaching and learning. There is no comprehensive study to typify the recent contributions of TES. In this light, the aim of the study is to understand the progress of the research on teacher education for sustainability in terms of yearly publications and citations, trending research papers, productive authors, institutions and countries and thematic areas of research. To achieve the aim of the study, we analyzed documents indexed in the online Scopus database over three decades starting from 1991 to 2020 by using bibliometric analysis. The data are visualized by using data visualization tools, such as VOSviewer and Tableau.

Methodological Framework

Bibliometric analysis provides an overview of the growth, progress and evolution of research in a specific area or field of study over a period of time by using various advanced tools (Benckendorff, 2009; Gavinolla et al., 2022). It is commonly used to understand and assess research impact and influence (Cunill et al., 2019). To be specific, analysis provides a detailed overview of progress of discipline in terms of the research themes, most cited documents and productive authors, journals and countries, impact and influence of documents published in a particular area (Diodato, 1994; Raghunatha et al., 2019). The authors used Scopus database for the study, as Scopus is the largest abstract indexing database (Burnham, 2006; Ramos-Rodrigues & Ruis-Navarro, 2004). The authors used VoS viewer (Van Eck & Waltman, 2010; Gavinolla et al., 2021), and Tableau (Hallinger & Kovačević, 2019) to analyze and visualize the data.

The authors carried out a bibliometric analysis in December 2020, applying keyword search "sustainability AND teacher AND education". Document search strategy included article title, abstract and keywords. Open access and other publications were considered. Only articles published in the English language were searched. As a result, a total of 1,782 documents were found and the same documents were considered for further analysis. Documents included Articles (1303), Conference Papers (227), Book Chapters (177), and Reviews (75). The export documentation setting included citation information, bibliographic information, abstract and keywords, funding and other details. Data were exported into comma-separated values (CSV) with excel spreadsheet and, in addition, manual coding and data entry were applied, wherever necessary. VOSviewer and Tableau were employed for the analysis and visualization of the data.

Results

The section deals with research output of TES in terms of year-wise publications and citations, most frequently published journals and authors. Output of the most contributing institutions by affiliation, most contributing subject areas, countries, funding sponsors, frequently cited articles and keyword analysis is shown.

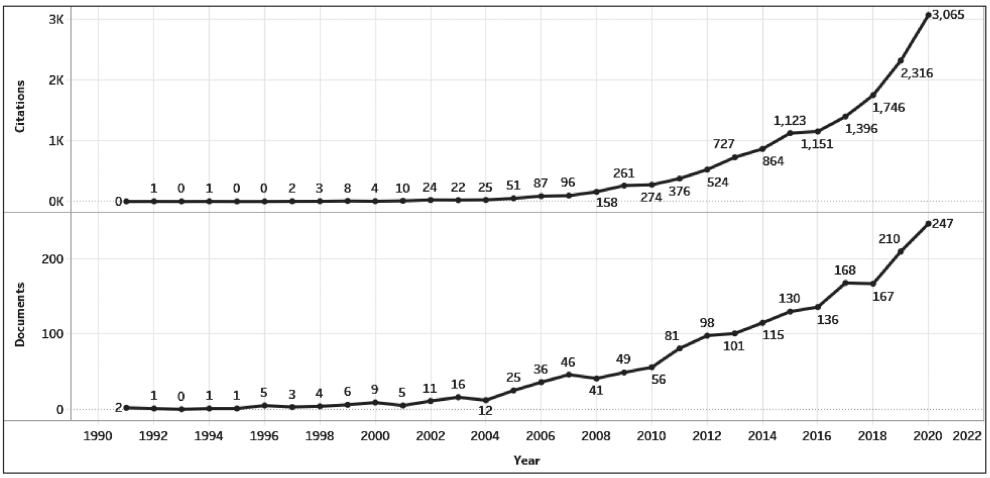
Year-Wise Publications & Citations

The number of documents published on TES over three decades starting from 1990 to 2020 is presented in Figure 1. The first document was published on TES related aspects in 1991, and there were no publications before that. Study results show that the

number of publications increased in the reporting period. From 1991 to 2000, there were only 32 publications with an average of 3 documents per year. The number of documents published on an average from 2001 to 2010 was 30 with 297 documents in total. Subsequently, the trend is continued exponentially from 2010 to 2020, and during this time each year there were minimum 81 to maximum 247 documents with on an average of 145 documents per year. Similarly, the citation analysis shows that there is an increased influence over the years. However, until 2000 there were few citations with an average of 2 per year. Later from 2001 to 2010, the number of citations increased significantly with an average of 100 citations per year. In the last decade, the number increased exponentially with an average of 1329 citations per year and the year 2020 alone received 3065 citations.

Figure 1

Year-Wise Publication Output on TES

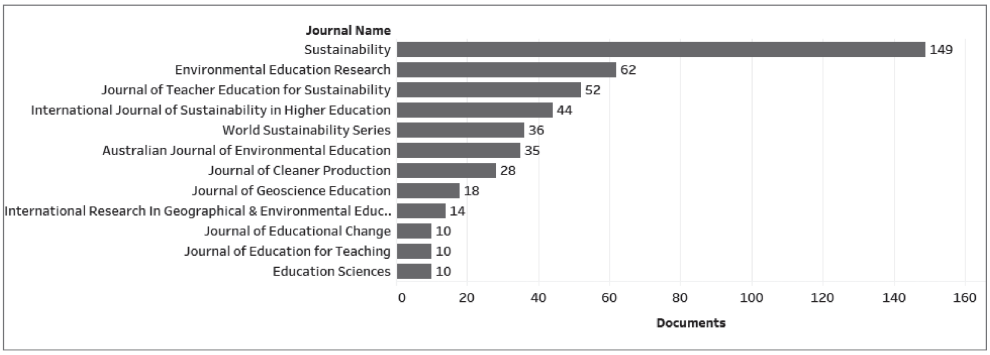


Journal Wise Publication Output

Most productive journals in terms of publications, particularly journal articles related to the TES, are shown in Figure 2. Top ten journals that have published a minimum of 10 articles are shown in the figure. The journal "Sustainability" (Switzerland) ranked first with 149 documents followed by the journal "Environmental Education Research" in the UK with 62 articles, and "Journal of Teacher Education for Sustainability" (Latvia) with 52 documents. The journal focusing on sustainability education "International Journal of Sustainability in Higher Education" ranked fourth with 44 documents and "World Sustainability Series" ranked fifth with 36 documents. Remaining journals that are shown in the figure ranked sixth to twelfth, respectively, with a minimum of 10 articles.

Figure 2

Journal Wise Publication Output on TES

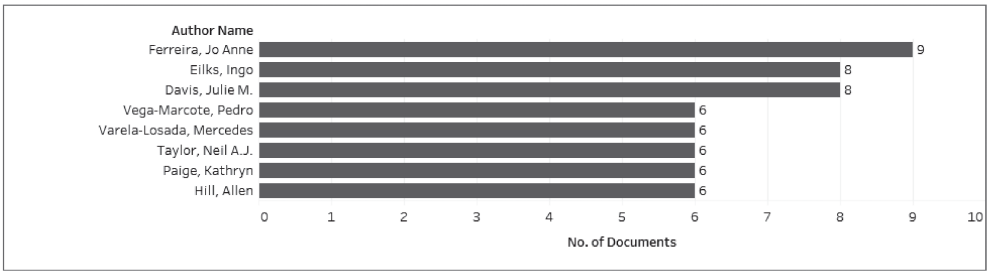


Most Productive Authors Wise Publication Output

Authors who have contributed the most on TES with a minimum of 6 to a maximum of 9 documents are shown in Figure 3. *Ferreira, Jo Anne* affiliated to *Southern Cross University* (Australia) contributed the most to the teacher education and sustainability related research and ranked top with 9 documents. *Davis, Julie M.* affiliated to *Queensland University of Technology QUT* (Australia) and *Eilks, Ingo* affiliated to *University of Bremen* (German) contributed to TES with 8 documents each. Remaining authors, namely *Hill, Allen* affiliated to *Ara Institute of Canterbury* (New Zealand), *Paige, Kathryn* affiliated to *University of South Australia* (Australia), *Taylor, Neil A.J.* affiliated to *University of New England* (Australia), *Varela-Losada, Mercedes* affiliated to *Universidade de Vigo* (Spain) *and Vega-Marcote, Pedro* affiliated to *Universidade da Coruña* (Spain) contributed to teacher education and sustainability related research with 6 documents each.

Figure 3

Most Productive Authors on TES



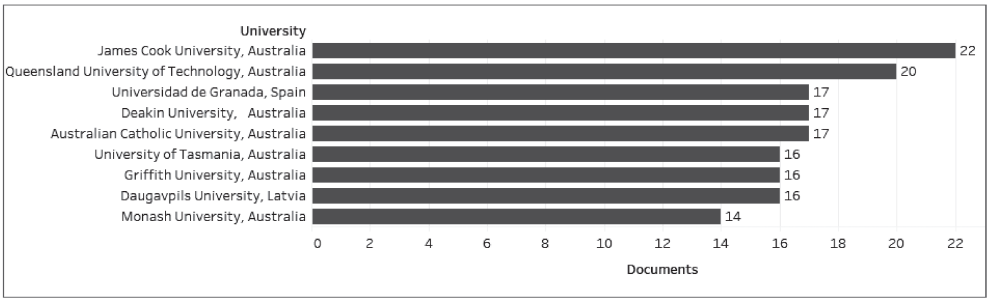
Authors' Affiliation Wise Publication Output

Research output based on the author affiliation is shown in Figure 4. There were 9 organizations in the list of most contributed organizations that contributed with a minimum of 14 documents to and a maximum of 22 documents. *James Cook University*

(Australia) contributed the most with 22 documents and ranked number one followed by *Queensland University of Technology* (Australia) with 20 documents. *Australian Catholic University, Deakin University* (Australia) and *Universidad de Granada* (Spain) ranked third, fourth and fifth, respectively, with 17 documents each. Other universities such as *University of Tasmania*, *Griffith University* (Australia) and *Daugavpils University* (Latvia) contributed to TES with 16 documents each. *Monash University* (Australia) contributed to TES with 14 documents. Surprisingly, Australia contributed the most to TES related research, followed by Spain and Latvia.

Figure 4

Most Productive Organizations Wise Output on TES

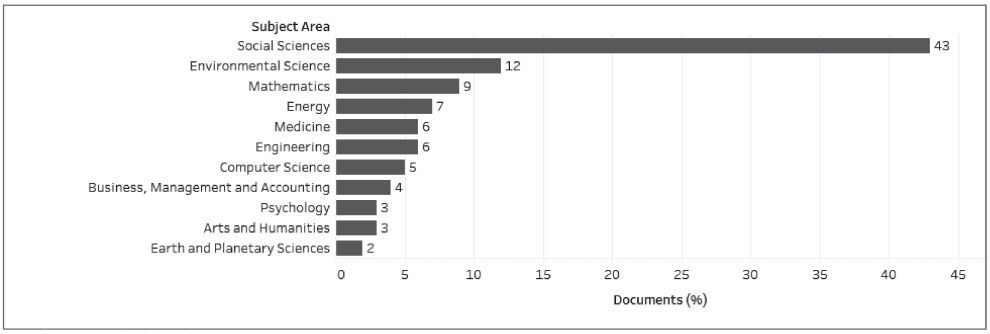


Subject Area Wise Publication Output

Subject area wise publications are shown in Figure 5. Based on the findings of the research, there were 43 documents published in the subject area of *Social Science,* followed by *Environmental Science, Mathematics, Energy, Medicine* and *Engineering* with 12, 9, 6, and 6 documents, respectively. Other subject areas such as *Computer Science*, *Business, Management and Accounting, Psychology, Arts and Humanities*, *and Earth and Planetary Science* are placed in top eleven subject areas wise publication with 5, 4, 3, 3 and 2 documents, respectively.

Figure 5

Subject Area Wise Publication Output on TES



Country Wise Publication Output

Most contributed countries with a minimum of 64 to a maximum of 379 documents are shown in Figure 6. *The United States of America* is the leading country contributing the most with 379 documents, followed by *Australia* with 234 publications. *The United Kingdom* and *Spain* ranked third and fourth with 177 and 135 documents, respectively. Remaining countries such as *Sweden, Canada and Japan* published 69, 67 and 64 TES related documents, respectively.

Figure 6

The Most Productive Country on Research Related to TES

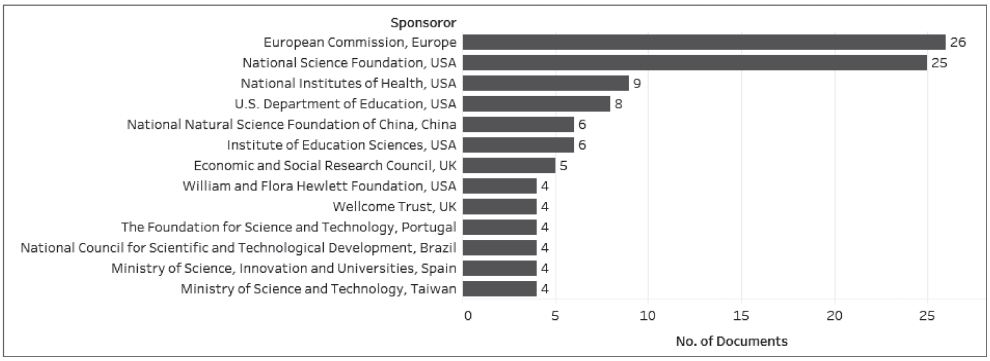


Funding Sponsor Wise Publication Output

Funding sponsor organizations that contributed the most on TES with a minimum of 4 documents and a maximum of 26 documents are shown in Figure 7. Organizations such as *the European Commission* (Europe) ranked first with 26 documents, followed by the *National Science Foundation* (the USA) that sponsored 25 documents and ranked second. *National Institutes of Health* and *U.S. Department of Education* (the USA) ranked third and fourth with 9 and 8 documents, respectively. Other institutions such as *Institute of Education Sciences* (USA) and *National Natural Science Foundation of China* (China) sponsored 6 documents each. The *Economic and Social Research Council* (the UK) sponsored 5 documents, and the remaining institutions, namely the *National Council for Scientific and Technological Development* (Brazil), *European Social Fund* (Europe), *The Foundation for Science and Technology* (Portugal), *Ministry of Science, Innovation and Universities* (Spain), *Ministry of Science and Technology* (Taiwan), *Wellcome Trust* (the UK), and *William and Flora Hewlett Foundation* (the USA), sponsored 4 documents each.

Figure 7

Funding Sponsor Wise Publication Output on TES



Analysis of the Most Cited Documents

The most frequently cited documents with a minimum of 106 citations on TES are shown in Table 1. The review article focusing on professional development of teacher "Teacher Professional Development in Teaching and Teacher Education Over Ten Years" by Avalos (2011) is the most cited article with 548 citations. "Sustainability of Teacher Implementation of School-Based Mental Health Programs" by Han and Weiss (2005) received 334 citations. Other articles focused on sustainability teacher education received the number of citations ranging from 162 to 334.

Table 1

Top Ten Most Cited Documents on TES

Authors	Publication year	Document title	Journal title	Citations
Avalos	2011	Teacher Professional Development in Teaching and Teacher Education Over Ten Years	Teaching and Teacher Education	548
Han & Weiss	2005	Sustainability of Teacher Implementation of School-Based Mental Health Programs	Journal of Abnormal Child Psychology	334
Hargreaves & Goodson	2006	Educational Change Over Time? The Sustainability and Non-Sustainability of Three Decades of Secondary School Change and Continuity	Educational Administration Quarterly	235
Steiner & Posch	2006	Higher Education for Sustainability by Means of Transdisciplinary Case Studies: An Innovative Approach for Solving Complex, Real-World Problems	Journal of Cleaner Production	166
Svanstrom et al.	2008	Learning Outcomes for Sustainable Development in Higher Education	International Journal of Sustainability in Higher Education	162

See next page for continuation of table

Continuation of Table 1

Lans et al.	2014	Learning Apart and Together: Towards an Integrated Competence Framework for Sustainable Entrepreneurship in Higher Education	Journal of Cleaner Production	135
Hoelscher et al.	2004	School-Based Health Education Programs can be Maintained Over Time: Results From the CATCH Institutionalization Study	Preventive Medicine	127
de Boer et al.	2010	Sustainability of Teacher Expectation Bias Effects on Long-Term Student Performance	Journal of Educational Psychology	119
Wals	2010	Mirroring, Gestalts Witching and Transformative Social Learning: Stepping Stones for Developing Sustainability Competence	International Journal of Sustainability in Higher Education	109
Halme	2001	Learning for Sustainable Development in Tourism Networks	Business Strategy and the Environment	106

Keyword Analysis

Keyword analysis provides analysis and visualization of research themes by using authors' keywords in a particular area of research (Kolle et al., 2018). Further, keywords can be analyzed to know the temporal evolution of research themes. Decadal evolution and overall research of themes of TES is displayed in the figures below. Figure 8 shows the overall analysis of keywords provided by author(s). According to the results, there are 4179 keywords, which meet 174 thresholds with a minimum occurrence of five. Sustainability related themes include pedagogy, e-learning, primary education. Teacher education is the second most research area followed by education for sustainable development and early childhood education. Technological aspects including e-learning, blended learning and MOOCs are the most focused areas. Methodological aspects include action research, evolution and qualitative research. Figures 9–11 show the temporal evolution of decade wise research themes. The main research themes from 1991 to 2000 were sustainable development, education for sustainability, Agenda 21, sustainable development education, pre-service professional development, in-service professional development, global change in education and environmental education, as well as evolution method (see Figure 9). The main research themes from 2001 to 2010 include sustainability, education for sustainable development, early childhood, teachers, schools, teacher training, environmental education and attitudes (see Figure 10). There is a shift in the research focus from environmental education to teacher training, teachers, education, values, school, and training, teaching and education policy. In the last decade (Figure 11), there was an increased importance of research and research themes. The period of 2011–2020 highlighted the growing researchers' interest in such themes as higher education, inclusive education, innovation, physical activity, cultural sustainability, system thinking, curriculum development, sustainability competencies, project-based learning, etc.

Figure 8

Analysis of Authors' Keyword of Research Themes on TES

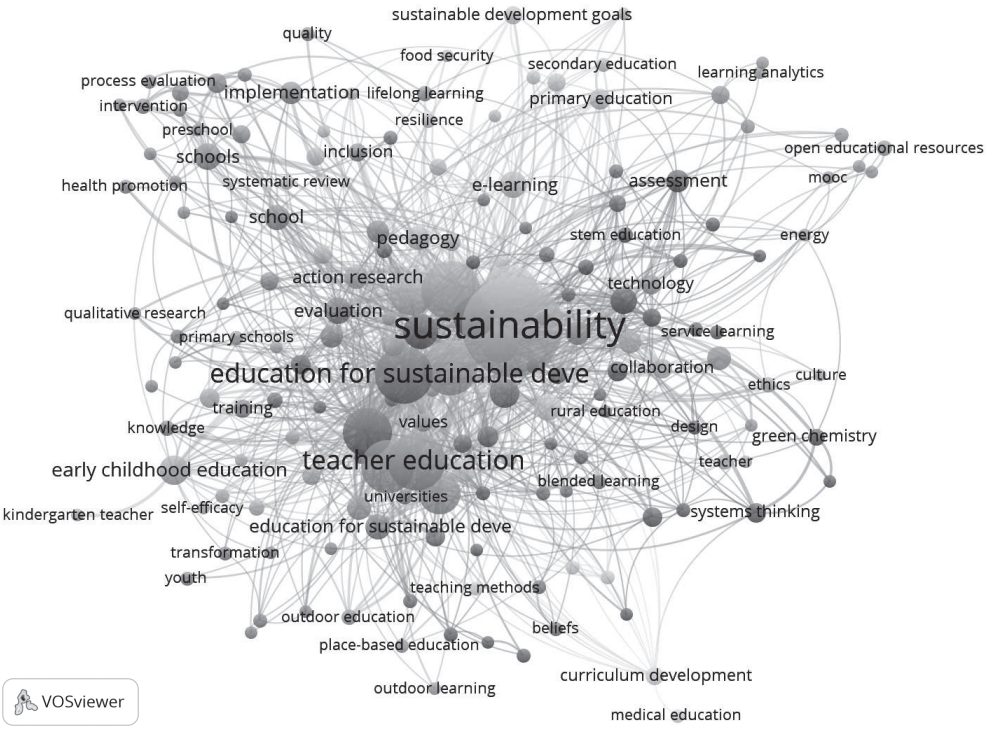


Figure 9

Analysis of Authors' Keywords of Research Themes on TES, 1991–2000

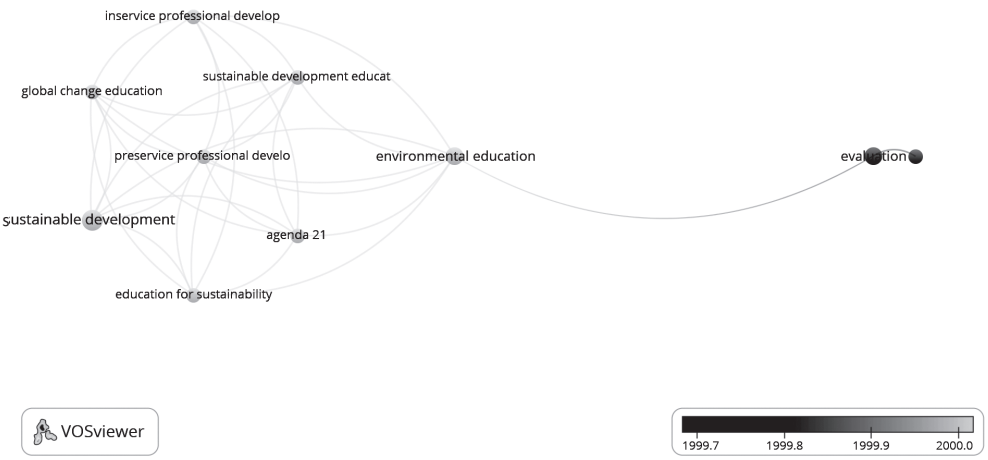


Figure 10

Analysis of Authors' Keywords of Research Themes on TES, 2001–2010

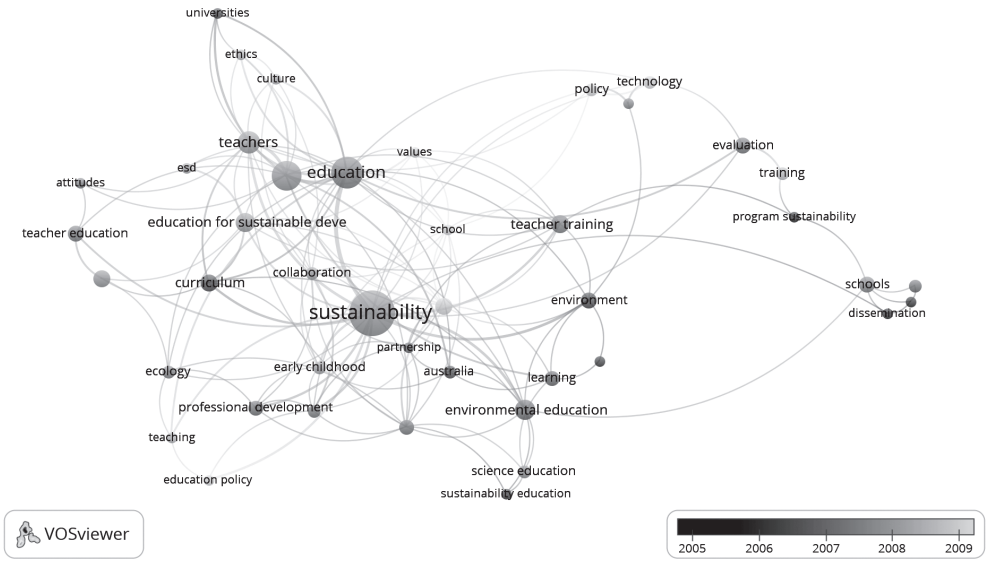
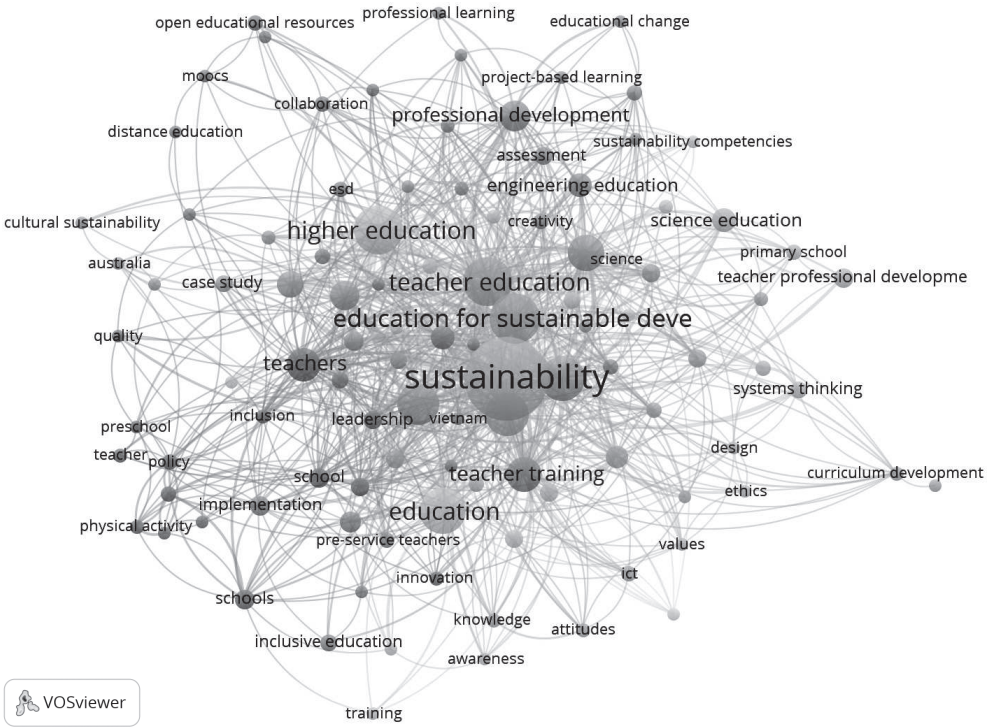


Figure 11

Analysis of Authors' Keywords of Research Themes on TES, 2011–2020



Discussion and Conclusion

The authors have examined the state of the research on the TES in terms of growth, influence, significant area of research by using the bibliometric analysis tool. Bibliometric analysis on TES has demonstrated that teacher education plays an important role in educating the students and developing awareness of sustainability, leading to a broader goal of sustainable development.

In this regard, yearly progress of the published documents shows the increased importance and focus of the research (Côrtes & Rodrigues, 2016; Alejandro-Cruz et al., 2019). It is evident in this study that the yearly progress of publications focused on TES has increased significantly. Until 2004, there were few publications and their number increased mainly from 2005. The decade from 2005 to 2014 was declared as ESD (UNESCO, 2005). A recent review paper examining the perceptions of education for sustainable development (Goller & Rieckmann, 2022), and other studies, such as emergence of alternative working environment for sustainability through education, substantiate the emerging and important aspects of the research on TES (Salīte et al., 2022; Rozentale et al., 2021). Thus, it may be asserted that during the ESD decade and further on, the research aspects of the TES attracted increasing attention of scientists (Pegalajar-Palomino et al., 2021). Citation analysis allows exploring the evolution, quality and depth of the scientific literature in a particular field (Kolle et al., 2018). Citations on the TES increased significantly from 2005; it was further witnessed exponentially in the last decade. Thus, it can be ascertained that the decade of ESD has strong influence on other fields of study as well. Publication of the research output in the standard journals shows the importance and influence of the topic. The research output of the TES is published in the most standard and high ranked journals with good quartile and cite score. The most frequently published journals on the topics of TES have a minimum quartile of two to three. The most cited papers are not published in thematic journals on sustainability and teacher education.

Productivity of the research explains performance and importance of the research area by a particular institution. It will further allow the government and other agencies to prioritize the funding for the future research (Law & Chon, 2007). The authors tried to examine the important institutions involved in the research area of TES, based on the authors' affiliation. Most of the universities located in Australia contributed the most to the TES research; they include *James Cook University*, *Queensland University of Technology*, *Catholic University* and *Deakin University*. It should be noted that *Daugavpils University* from Latvia contributed the most from Europe after *Universidad de Granada* in Spain. This may be due to the committed people at the UNESCO Chair on the Interplay of Tradition and Innovation in Education for Sustainable Development (ESD) at Daugavpils University, Latvia and also the Journal of Teacher Education for Sustainability. Funding agencies may consider the above-mentioned institutions for the future research on TES. Researchers may consider the Journal of Teacher Education for Sustainability for the detailed literature and research results on TES.

Subject area wise publication output of TES shows the important subject area contribution and its interconnectedness. In the context of TES, the subject areas such as Social Science, Environmental Science, Mathematics, Energy, Medicine and Engineering contributed the most. There are several studies that mention the importance of using digital learning and teaching tools for ESD, and EDUsummIT "Rethinking Learning in the Digital Age" in 2017 discussed the same issues (Said, 2018). In this regard, it is im-

portant to focus the research in the subject areas such as Computer Science as the present study shows that there is a limited contribution from this area. Other subject areas such as Business, Management and Accounting, Psychology, and Arts and Humanities contributed the least. However, it is important to note that these areas can contribute more towards creating values, ethical business practices for the future generation. Considering this gap, there is a need to have more research contribution from the mentioned areas. Scientific production of research on implementation of sustainability curriculum in higher educational institutions shows that western countries produced the most compared to other countries (Weiss & Barth, 2019). The study results substantiate the same that the research on TES is produced mainly by the most developed countries such as the United States of America, Australia, the United Kingdom, Spain, Sweden, Canada and Japan. At the same time, the USA ranks 31st in Sustainable Development Report 2020, Australia – 37th and Sweden – takes the first place (Sachs et al., 2020). The USA is still among few countries that have not signed Kyoto Protocol on global climate change. From this point of view, it can be concluded that sustainable teacher education is studied both in countries where it is a "hot" theme, including in the political arena, and in countries that are progressing successfully and purposefully in achieving the objectives of sustainability, as they have already experienced in subject. This may be a significant aspect for these countries due to concern over the sustainability for teacher education or sustainable development.

Bibliometric analysis can be used to measure importance and priority of the public or industry funded projects or funding agencies (Güzeller & Çeliker, 2018). Funding organizations such as European Commission (Europe), National Science Foundation, National Institutes of Health, U.S. Department of Education (the USA) and National Natural Science Foundation of China (China) have the highest priority for the research on TES. Citation is an evidence for the quality of the research output and its impact in a particular discipline (Güzeller & Çeliker, 2018). Top ten documents published in the area of TES received a minimum of 100 plus citations. The most influential research related to TES includes teacher professional development, implementation of school-based programs, sustainability and non-sustainability aspects, innovation in higher education, learning outcomes in higher education, learning apart and together, integrated competence framework for sustainable entrepreneurship and teacher expectation bias effects.

Keyword analysis provides the research themes and temporal evolution of research themes in a particular area of research (Kolle et al., 2018). Sustainable development, education for sustainability, Agenda 21, sustainable development education, pre-service professional development, in-service professional development, global change in education and environmental education were the major themes till 2000. However, there was a shift in the research focus from environmental education to teacher training, teachers, education, values, school, and training, teaching and education policy. In the last decade, inclusive education, higher education, innovation, physical activity, cultural sustainability, system thinking, curriculum development, sustainability competencies, project-based learning received more importance. Fortunately, the research themes on e-learning, blended learning and MOOCs also attracted scientists' attention in the last decade. It shows that there is a research gap in relation with blended learning, digital learning, other modern tools and techniques and Agenda 2030 of SDGs. Future research of the TES should concentrate on these broader aspects to achieve the goal of sustainable develop-

ment particularly in uncertainty conditions as pandemics, wars, economic crisis. Future research should include, particularly, the use of information and communication technologies such as digital technologies, digital media, virtual reality, and artificial intelligence to understand, learn and teach various sustainability aspects of teacher education. Outcome of the study results, particularly the evolution, growth, performance and research topics of teacher education for sustainability would provide reference for understanding the existing landscape of the scientific literature and research gap that need to be filled in the future, both for the industry and academia.

There are several limitations in the study, which can be present the areas of future research. Data for the study were collected from online database Scopus. However, there were several articles published in various journals that are not indexed in Scopus and they were not considered in the study taking into account the issue of certified knowledge. Future studies should focus on other well-known databases, such as Web of Science. Further, there is a scope to perform the co-word analysis, co-citation and co-authorship analysis, to learn more about research collaboration of authors on TES. Future studies can also examine the influence and impact of the research by using the citation overview of the other fields. Despite these limitations, the authors tried to provide a considerable contribution towards literature on TES, both for the academic and practitioners, enabling them to carry forward the research agenda of the TES.

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