The Development of Circular Economy Teaching in Business: A Bibliometric Analysis (1994-2022)

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Abstract: This study aimed to evaluate the development of research on CE teaching in higher education institutions through systematic mapping of scientific literature. This study used a bibliometric approach to map research literatures on CE teaching in higher education using Scopus extracted metadata. The investigation yielded 232 publications, including articles (124), conference papers (59), book chapters (14), conference reviews (13), books (7), editorials (2) and short survey (1). The major findings are: (1) research on CE teaching emerged in 1994; (2) there is a quite limited number of authors, institutions, and countries that produced research in this field; (3) research collaboration is not established significantly; (4) two journals stand out in this field are Sustainability and Journal of Cleaner Production; and (5) general themes of current articles include learning activities, classroom management, higher education, technical aspects, learning output and product design. The findings will be valuable for readers to define the role model in writing about CE teaching in business, identify potential collaboration with authors and institutions across countries, and develop new issues on CE teaching in the existing areas of research or, otherwise, develop the existing issues in new areas of research. Practically, this study provides a comprehensive and relevant review of the literatures on CE teaching that can be used to teachers, lecturers, and education policy makers to determine the better framework to introduce Circular Economy for business students gradually and continuously.

Keywords: Circular Economy, Sustainable Economy, Teaching, Business, Bibliometric

1. Introduction

The campaign for transforming Linear Economy into Circular Economy (CE) is performed massively recently. It becomes even more urgent due to the rapid decline in environmental condition in almost every part of the Earth. Therefore, many scientists are eager to participate in this transformation by conducting research and publishing its results in internationally recognized journals to spread their "CE" messages to the world community. Originally, the term "Circular Economy" was introduced in 1990 by Pearce &Turner and began adopted widely (Blomsma & Brennan, 2017). Initially, CE merely described how feedback loop existed between natural stocks and use of nature as a place to dispose of waste. As research on it developed, scientists recently developed a new concept of CE referring to the concept and practice on how to extend product life cycle. Nowadays, the concern about cleaner production is no longer only focused on production sector, but it is now an important part of the vision, strategy and policy in service sector, such as health, tourism, and forestry (Hens et al., 2018).

Regardless of the rapid development in CE research, Romero-Luis et al. (2021) revealed that the scope of scientific literatures in this area was limited, indicating that research was still in its early stage. This study concludes that research on CE is at a low level of maturity. Prieto-Sandoval et al. (2018) stated that a consensus was needed on the basic understanding of CE framework and its relationship with environmental-based innovation since researchers studying CE proposed different approaches and applications. Meanwhile, Corvellec et al. (2021) proposed critical issues that CE might need to address including modesty, concreteness, inclusiveness and transparency. Given the fact that research on CE is still in its early stage in confirming established theory, the world needs a change in economic activity pattern, especially due to linear economy's detrimental effect. Moreover, a wide range of stakeholders' contribution is needed to encourage transition tow CE.

Various stakeholders had made efforts recently to transform linear economy into circular economy. Researchers and companies continuously performed evaluation for cleaner production practices (Bocken et al., 2022; Diaz et al., 2022; Lin, 2018; Ripanti & Tjahjono, 2019; Susanty et al., 2020). Small and Medium Enterprises (SMEs) attempted to provide value to Centobelli customers by implementing CE (Chaudhuri et al., 2022). Centobelli et al. (2020) attempted to map the literatures on designing of business model in CE. Even legal experts had studied consumer protection in CE products (Mak & Terryn, 2020). However, Kirchherr & Piscicelli (2019) stated that a group of stakeholders was underrated for joining "the club", lecturers in higher education. Paradoxically, Kopnina (2018) highlighted that "Education for sustainability can certainly help to "engage the unengaged"–students who just want to get a good internship and eventually a job without the burden of thinking about the trade-offs of economic development and humanity's dire predicament" (page 22). Therefore, it is essential to associate CE with education through research and practices.

The main objective of this bibliometric analysis is to provide the research map of CE teaching by identifying: (1) the publication trends; (2) leading authors, institutions, and countries/territories; (3) collaborative networks between authors, institutions, and countries/territories; (4) disciplines underlying the foundations of CE teaching; and (5) keywords of research on CE teaching. Each point will be presented in different table and figure for readers' easier understanding of the information presented. The findings will be valuable for readers to define the role model in writing about CE teaching, identify potential collaboration with authors and institutions across countries, and develop new issues on CE teaching in the existing areas of research or, otherwise, develop the existing issues in new areas of research.

2. Pedagogy of Circular Economy Teaching in Business

The first literature traced on CE teaching discussed how to have MBA students in Boston University recognized environmental problems in 1994. Before 2011, students of Higher Education Institutions (HEIs) were clearly the main target in CE teaching, both of bachelor degree (Cowan et al., 2010; Geng et al., 2009; Hallam et al., 2008) and master degree (Ziv, 2008). The research article discussing CE teaching outside HEIs was initially written by (Singseewo & Jintana, 2011) on how to develop learning activities to teach the philosophy of sustainable economy for elementary school students in 2011 and four years later (Kibuka-Sebitosi, 2015) attempted to develop a model for international collaboration and partnership to teach sustainable development for basic education in South Africa. They were later followed by other researchers such as: (Buil et al., 2017; Jääskä et al., 2021; Messnarz et al., 2017; Occhioni & Paris, 2021; Ryplova & Pokorny, 2020) who published their papers on CE teaching in elementary school; (Stacchiotti et al., 2019; Tolppanen et al., 2019) who promoted case study in secondary school; and (Leire et al., 2016) who designed Massive Online Open Courses (MOOC) for anyone who wanted to study sustainability at university level.

In terms of the title of courses in business discipline, some courses were named Business-Environment (Rands, 1994), Business and Engineering (Hallam et al., 2008), Green Economy (Newton et al., 2014), Sustainable Resources Management (Williams et al., 2018), Bioeconomy (Nibbi et al., 2019; Pubule et al., 2020), and Business Application (Minguez et al., 2020). Regardless of the courses, the classroom management approaches were quite similar. The learning activities mainly included experiential learning activities (problem-based learning, project-based learning, and case-based learning); collaborative learning with industries and research institutions. Some papers reported the use

of game-based learning (Caeiro-Rodríguez et al., 2021; de la Torre et al., 2021; Fraccascia et al., 2021; Jääskä et al., 2021; Kirchherr & Piscicelli, 2019; Whalen et al., 2018) and online or virtual classes (Contreras-Taica et al., 2022; Leppänen & Kuula, 2019; Occhioni & Paris, 2021). The structures of courses on CE concept varied. Some courses exclusively delivered CE materials in courses of master or doctoral program. In bachelor program, the materials on CE were mostly included into regular courses in the form of case study for two to six meetings. As an alternative, some universities set the courses as optional and multidisciplinary courses that students from any faculty across the disciplines could access.

The experiential learning activities used in CE teaching in business were usually designed in a case study that raised partner companies' problems for solutions by taking CE values and principles into account. The syntax of classroom activities refers to common syntax of problem-based learning or project-based learning: introducing students to a problem/project/case, organizing students to learn, assisting independent or group investigations, developing and presenting works and exhibitions, analyzing and evaluating learning process. The collaborative approach in CE teaching was found in some literatures, that lecturers and HEIs managers actively communicated with companies and invited them to classes to share their technical problems related to CE implementation in their organization. These problems were then formulated into reality-based case study that students must solve through multidisciplinary-based research.

Discussions on assessment in CE teaching were found limited in the collective dataset. Only a few researchers wrote about the assessment instruments used in CE teaching. Interestingly, distinguished patterns were found during the process of analysis on assessment instruments. Besides questionnaire and interview, assessment for elementary and secondary school tended to add cognitive evaluation instruments, such as multiple choices, written test, pre-test and post-test (Messnarz et al., 2017; Occhioni & Paris, 2021; Ryplova & Pokorny, 2020; Singseewo & Jintana, 2011) to measure students' understanding of the materials delivered. On the other hand, assessment process at university level used self-assessment instruments (using questionnaire, report, reflection, or feedback) and specific evidence-based assessment, such as specific matrix (Ashby & Vakhitova, 2018; Bugallo-Rodríguez & Vega-Marcote, 2020; Luthe et al., 2017; Murga-Menoyo, 2014; Pereira & Frederiksson, 2015; Sadowski, 2021; Sánchez-Carracedo et al., 2020), and project output or final product (Bonoli et al., 2018; Buil et al., 2017; Espiritu & Taboada, 2011; Hallam et al., 2008; Hoffman et al., 2021; Leal et al., 2020; Osterwood et al., 2011; Rizzon, 2020; Whitehill et al., 2022).

3. Research Methodology

This study used a bibliometric approach to map research literatures on CE teaching in higher education using Scopus extracted metadata by Elsevier. Gureyev & Mazov (2022) stated that through bibliometric evaluation, publication ethics related issues could be reduced by strengthening the principles of integrity in the publication process and increased sharing of original studies. Scopus and Web of Science (WoS) are the two main bibliographic databases generally accepted as the most comprehensive data sources for numerous purposes (Pranckutė, 2021; Zhu & Liu, 2020). Over the years, Scopus has earned its distinguished as a comprehensive source of bibliographic data and has proven itself to be reliable and, in some respects, even better than WoS (Harzing & Alakangas, 2016; Pranckutė, 2021; Zhu & Liu, 2020). Scopus includes over 84 million records and 1.8 billion cited references since 1970 in social science, physical science, health science and life science (Elsevier, 2022).

3.1 Creation of Dataset

The search for dataset was conducted in the third week of April 2022 in Scopus.com database. Six key terms were input into the database to create a representative corpus of documents for the investigation: "circular economy" OR "sustainable economy" OR "green economy" AND "higher education" OR "teach" OR "teaching". This study kept the key terms as specific as it could to ensure the results were focused on researches and reviews on CE teaching in higher education. The investigation yielded 232 publications, including articles (124), conference papers (59), book chapters

(14), conference reviews (13), books (7), editorials (2) and short survey (1). For each document retained, the authors extracted bibliometric data regarding the year of publication, number of citations, author, institution, country, journal, cited references and keywords of the documents. The subject areas of publications detected varied, including social science (101), environmental science (86), energy (68), engineering (61), business, management and accounting (49), and many other subjects.

The limitation of the creation dataset process in this study is that the search with the keywords was exclusively conducted in the Scopus database. Therefore, relevant literatures published outside the Scopus database might have been excluded from this study. Nevertheless, the authors are confident that with the search method implemented in this study, there are valuable implications to develop the way scholars study CE and believe that this study will contribute a valuable research map for future researches' guide.

3.2 Data Analysis

Frequency distribution was used to determine the trend of direction in higher education research publications and citations on CE teaching. Frequency of publication and citation rank order were used to identify leading authors, institutions, and countries, and the mostly used keywords in the field. This study used VOSViewer software version 1.6.18 to explore and visualize relationships between authors, institutions, countries, journals, and terms in the database. VOSViewer is software available for free (www.vosviewer.com) for network data-based construction and visualization of bibliometric maps. In this software, the nodes were the objects of interest and represented the authors, institutions, countries, journals, and keywords. VOSViewer had three main panels to present research visualization: network visualization; overlay visualization, and density visualization (Jan van Eck & Waltman, 2022).

This study mainly used network visualization to show the clusters of each data and overlay visualization to identify the year of publication. These two visualizations were used to conduct co-authorship analysis to determine the leading authors, institutions and countries of articles on CE teaching published; co-citation analysis for examining which discipline research on CE teaching belonged to; and co-occurrence analysis for clustering the keywords of publications in the dataset to reveal general themes of CE teaching in educational institution researches. Additional information was presented in the Results and Discussion section to facilitate interpretation of co-authorship, co-citation, and co-occurrence of bibliographic maps.

4. Results and Discussion

4.1 Trends in publication on CE teaching

The dataset had 232 documents and had been cited 1,515 times within 28 years. The initial idea about CE teaching was actually found in 1994 when Rands (1994) wrote a conceptual paper in the Journal of Teaching in International Business entitled "Preparing students to work for sustainability: Teaching as if the earth's future mattered". However, after this first article, there was no other publication on CE teaching existing until 2008. Publications in the period of 2008-2012 on this topic fluctuated substantially. From 2013, the number of publications on CE teaching gradually increased and reached its peak in 2021 with 57 titles of publications. It was predicted that in the years to follow this number would keep growing exceed the total publications in 2021 since recently more authors focused on this topic. The number of publications on CE teaching is presented in Figure 1.

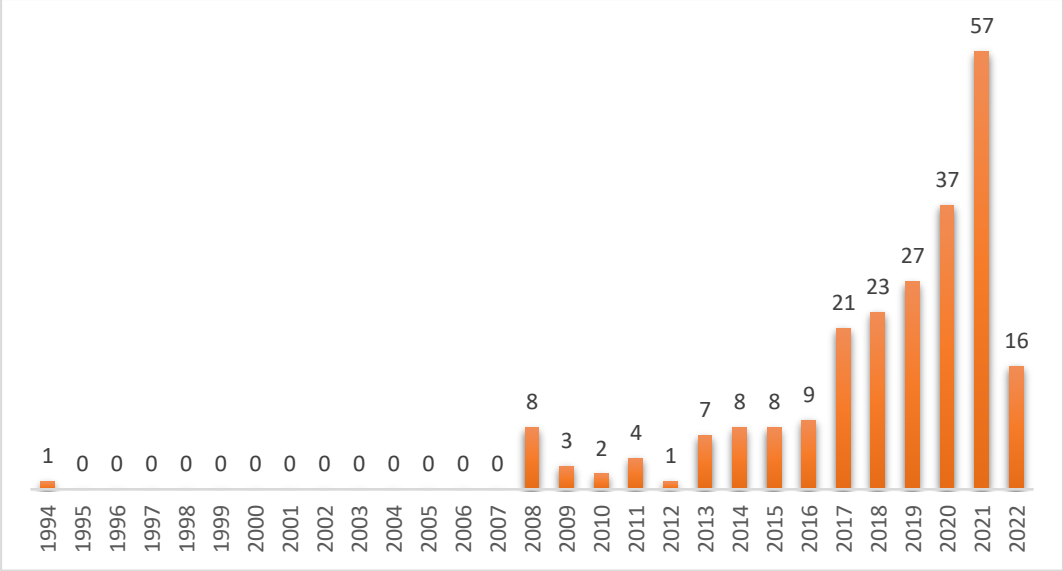

Fig. 1 The Number of Publication on CE Teaching (1994 – 2022)
(Source: www.scopus.com, 2022)

Publications with the highest number of documents are presented in Table 1, covering journals, proceedings, books, series, and lecture notes. Based on the dataset, Sustainability, a journal from Switzerland has the highest number published articles on CE teaching with 36 documents. The Journal of Cleaner Production is ranked second with 9 documents. Other sources, however, only have a small number of publications on this topic.

Table 1. Top journals on CE teaching

Journals/Proceedings/Books	**Documents**
Sustainability Switzerland	36
Journal of Cleaner Production	9
PICMET (Portland International Center for Management of Engineering and Technology) Proceedings	7
International Journal of Sustainability in Higher Education	6
Lecture Notes in Networks and Systems	5
ASEE Annual Conference and Exposition Conference Proceedings	3
Detritus	3
E3s Web of Conferences	3
Emerald Emerging Markets Case Studies	3
Energies	3
Environmental Education Research	3
International Multidisciplinary Scientific Geoconference Surveying Geology and Mining Ecology Management Sgem	3
Proceedings of the 45th Sefi Annual Conference 2017 Education Excellence for Sustainability Sefi 2017	3
Proceedings of the International Conference on Industrial Engineering and Operations Management	3
World Sustainability Series	3

Although Sustainability has more documents than the Journal of Cleaner Production, in terms of citations the latter journal is more popular than the former. From the top ten of the most influential publications by the number of citations, two articles in the Journal of Cleaner Production are presented in and no article from Sustainability is shown Table 2. The first place on the list is articles on the evolution of cleaner production written by Hens et al. (2018) which is cited 108 times. Changes of the

scope of the concept and application of cleaner production delivered in wide range in this article were a valuable contribution to develop other research and publication on CE teaching in many disciplines.

Table 2. Most influential publications by number of citations

Title	Journal	Year	Citations
On the evolution of "Cleaner Production" as a concept and a practice	Journal of Cleaner Production 172, pp. 3323-3333	2018	108
California Indians and Their Environment: An Introduction	Book *California Indians and Their Environment: An Introduction* pp. 1-490	2009	84
Factors influencing green purchase behavior of millennials in India	Management of Environmental Quality: An International Journal 29(5), pp. 798-812	2018	82
On water security, sustainability, and the water-food-energy-climate nexus	Frontiers of Environmental Science and Engineering 7(5), pp. 626-639	2013	80
Towards an Education for the Circular Economy (ECE): Five Teaching Principles and a Case Study	Resources, Conservation and Recycling 150,104406	2019	55
Twenty-first century education: Transformative education for sustainability and responsible citizenship	Journal of Teacher Education for Sustainability 18(1), pp. 48-56	2016	51
Mining and metallurgical wastes: A review of recycling and re-use practices	Journal of the Southern African Institute of Mining and Metallurgy 118(8), pp. 825-844	2018	49
'All they do is win': Lessons learned from use of a serious game for Circular Economy education	Resources, Conservation and Recycling 135, pp. 335-345	2018	49
Integrated circular economy and education model to address aspects of an energy-water-food nexus in a dairy facility and local contexts	Journal of Cleaner Production 167, pp. 1084-1098	2017	48
Education for the future? Critical evaluation of education for sustainable development goals	Journal of Environmental Education 51(4), pp. 280-291	2020	44

4.2 Leading authors, institutions, and countries/territories

The 232 articles in the dataset were published by 693 authors affiliated to 453 institutions in 80 countries worldwide. Table 1 shows the leading authors of research on CE teaching in higher education. Based on the dataset, H Kopnina has the highest number of articles on CE teaching published and D López is ranked second as the leading author in CE teaching with 3 documents published in Scopus about this topic. Meanwhile, A Azapagic, A Gallego-Schmid and JMF Mendoza have the same number of publications and citations with 2 articles and 63 citations each. As the CE teaching topic in higher economy is relatively new among researchers, only 21 out of the 693 authors produced at least 2 articles, which means 96.97% of the authors in our dataset published only 1 article.

Table 3. Top authors by number of publications and citations

No.	Author	Documents	Citations
1	H Kopnina	5	100
2	D López	3	1
3	A Azapagic	2	63
4	A Gallego-Schmid	2	63
5	JMF Mendoza	2	63

On the other hand, based on the number of citations, the composition of leading authors is quite different from the data presented in Table 3. As listed in Table 2, even Hens et al. (2018) are not included in the top 5 most productive authors, they had 108 citations from their one and only published paper on CE teaching entitled "On the Evolution of "Cleaner Production" as a Concept and a Practice" in the Journal of Cleaner Production published by Elsevier. This number of citations is slightly higher than that of H Kopnina as the most productive author in this field with 5 documents and 100 citations. In terms of published books, Lightfoot & Parrish (2009) were cited 84 times for their book entitled "California Indians and Their Environment". Besides, Chaudhary & Bisai (2018) had 82 citations from their research article published by Emerald in Management of Environmental Quality: An International Journal entitled "Factors influencing green purchase behavior of millennials in India".

Table 4 shows the leading institutions of research on CE teaching. Delft University of Technology in German is ranked first, followed by Universitat Politècnica de Catalunya in Spain with slightly less documents. Interestingly, all of the institutions listed are located in Europe. It is clear that Europe still dominates research and publications in this field although other continents have started research on CE teaching.

Table 4. Top institutions by number of publications and citations

No.	Institution/Organization	Country	Documents	Citations
1	Delft University of Technology	German	7	67
2	Universitat Politècnica de Catalunya	Spain	6	26
3	University of Southampton	United Kingdom	4	32
4	Universidad del Pais Vasco	Spain	4	10
5	Sapienza Università di Roma	Italy	4	18

The leading countries for the total researches on CE teaching published are presented in Table 5. It lists the top 10 countries which published at least 3 articles. Spain is the country with the highest number of publications with totally 28 articles, followed by the United States (22) and Italy (22). The United States and Italy have equal number of publications; however, the United States has more citations (237) than its counterparts (79) having it ranked second. Out of the 10 countries, 6 are located in Europe while the rest represents each of the other continents.

Table 5. Top countries by number of publications and citations

No.	Author	Documents	Citations
1	Spain	28	201
2	United States	22	237
3	Italy	22	79
4	Netherlands	19	241
5	United Kingdom	19	136
6	China	14	45
7	Portugal	12	27
8	South Africa	11	95
9	Australia	9	20
10	Finland	6	11

4.3 Collaborative networks between authors and countries

To figure out the pattern of scientific collaboration between authors, institutions and countries on CE teaching in higher education research, a series of co-authorship analyses were conducted. The Figure 2 depicts author collaboration in writing publications on CE teaching with at least 1 document published. Unrelated items were excluded in this analysis. Since the publications in this field were still greatly limited, the biggest set of connected authors only had 14 out of the 693 authors, divided into 2 clusters. This collaboration started by Segalas et al. (2017) who published an article entitled "Circular Design–Learning for Innovative Design for Sustainability: Eramus+ Knowledge Alliance Project for Sustainable Design" in Proceedings of the 19th International Conference on Engineering and Product Design. The same group of authors then invited other authors to collaborate in an article published in 2020 entitled "Learning Resources for Sustainable Design in Engineering Education" (Segalàs et al., 2020).

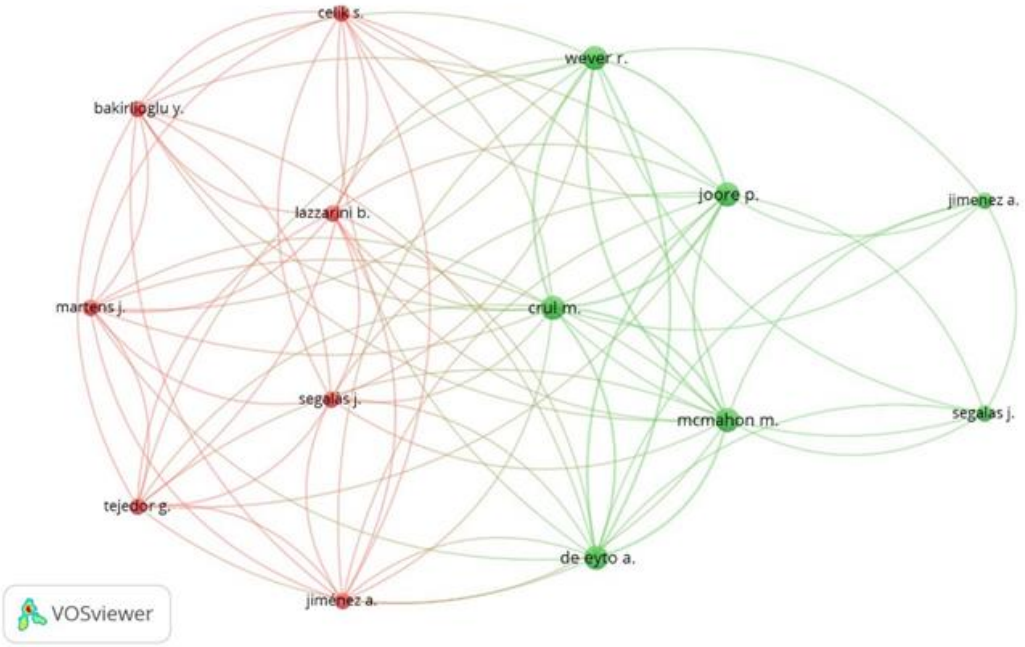

Fig. 2 Collaborative research between authors

Figure 3 represents research collaborations between countries. 39 out of 80 countries in the dataset were found having academic collaboration for at least 1 publication. There were 8 clusters in these collaborations with various countries involved. The big nodes represent the intensity of collaborations. Based on Figure 3, United Kingdom, Spain, Italy, Netherlands, and United States had more collaborative activities than other countries. Even if it ws dominated by European countries, Australia, China, and Turkey were in progress of collaborating with more authors around the world. The same was also attempted by Russia, Brazil, New Zealand, and other smaller-node countries in the figure.

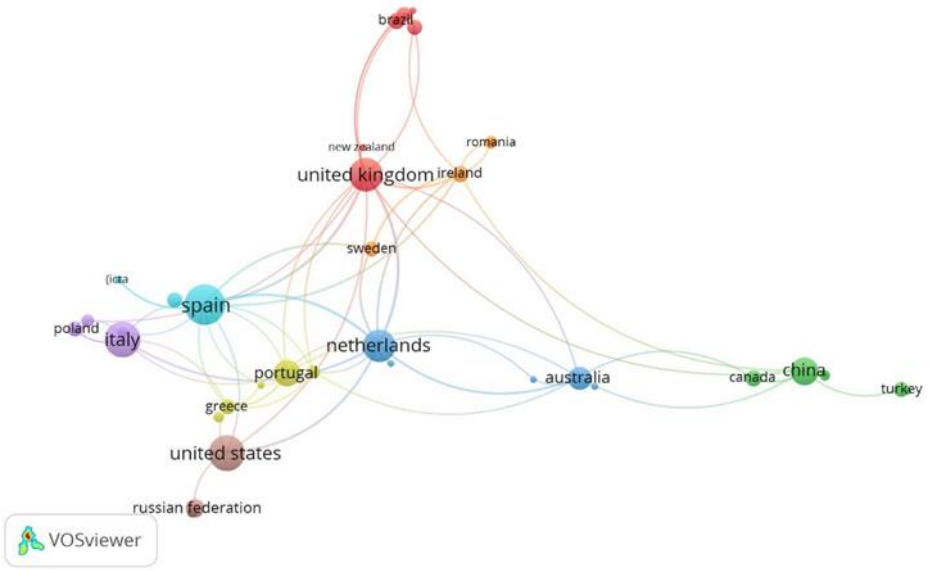

Fig. 3 Collaborative Research between Countries

Behl et al. (2020) stated that the way to measure research output effectively had not been discovered. However, one of the indicators was its qualitative (directly on the body of knowledge) and quantitative (on other researches by citations or collaborations) impacts. With research collaboration across institutions and countries increased, research results will be disseminated more widely. One of the strategies for wider dissemination of the research impacts is by collaborating with more productive foreign authors in the same field in big teams (Martinez & Sá, 2020).

4.4 Disciplines underlying the foundations of CE teaching in higher education

A co-citation analysis was conducted to analyze the background discipline(s) of research on CE teaching. There were publications with at least 20 citations including in this analysis (n = 5.018), leading to 21 items grouped into 4 clusters after eliminating unrelated items. Figure 5 shows the 4 clusters in different colors. The nodes represent journals of research published in the field and their sizes describe the number of co-citation relationships with other journals. The same cluster indicates that the journals therein have stronger co-citation relationships and can be interpreted in one discipline of knowledge.

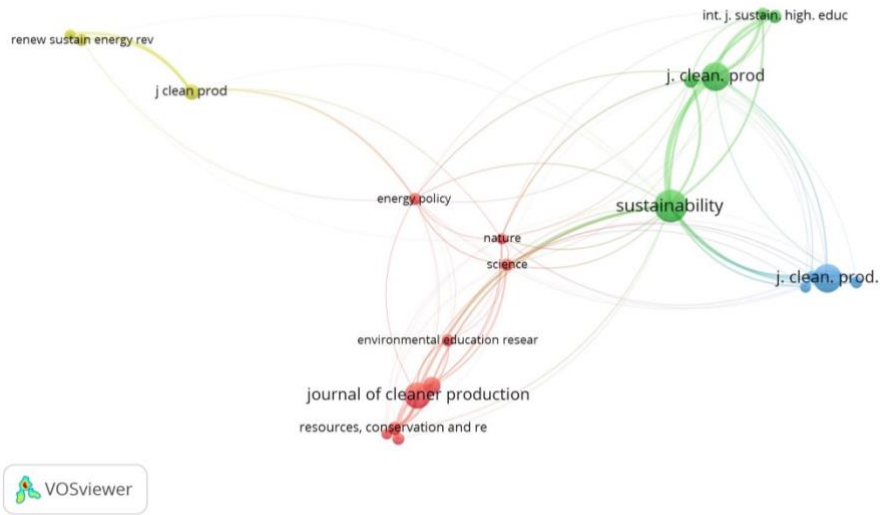

Fig. 4 Co-citation Data based Clustered Journal Network

Figure 4 describes that the researches on CE teaching develop from 4 different research disciplines. The red cluster is the biggest consisting of 8 journals: Ecological Economics, Environmental Education, Resources, Conservation and Recycling, Science, Waste Management, International Journal of Sustainability in Higher Education, Journal of Cleaner Production, and Journal of Industrial Ecology. The last three journals in red also form new, different cluster in green. The third cluster in blue has 3 journals: Energy Policy, Journal of Cleaner Production, and Nature. The fourth cluster in yellow includes Journal of Cleaner Production, Resources, Conservation and Recycling, and Sustainability. The last cluster in purple only has 2 journals: Handbook of North American Indians and University of California Publications in American Archaeology and Ethnology. A journal is of almost all clusters, that is an intriguing fact: Journal of Cleaner Production. Hens et al. (2018) found that recently cleaner production extends the spirit of sustainability in many life aspects and leads to interdisciplinary research. The last cluster reflects that the flexibility of CE topic results in its inclusion into disciplines that are way different from science or engineering.

4.5 General themes of research on CE teaching

A co-occurrence analysis was conducted to examine the general themes of publications on CE teaching in higher education. It analyzed the keywords in the titles, abstracts and keyword list in the dataset. The keywords eligible were those appearing at least 5 times in the dataset. Having unrelated items eliminated, co-occurrence analysis resulted in 6 clusters (n = 1.550; 59 met threshold). The size of nodes in the map represents the occurrence of each keyword. The closeness and thickness of lines connecting keywords describe the strength of co-occurrence between pairs of keywords. The color of keywords' nodes shows their cluster and can be interpreted as a general theme in the field.

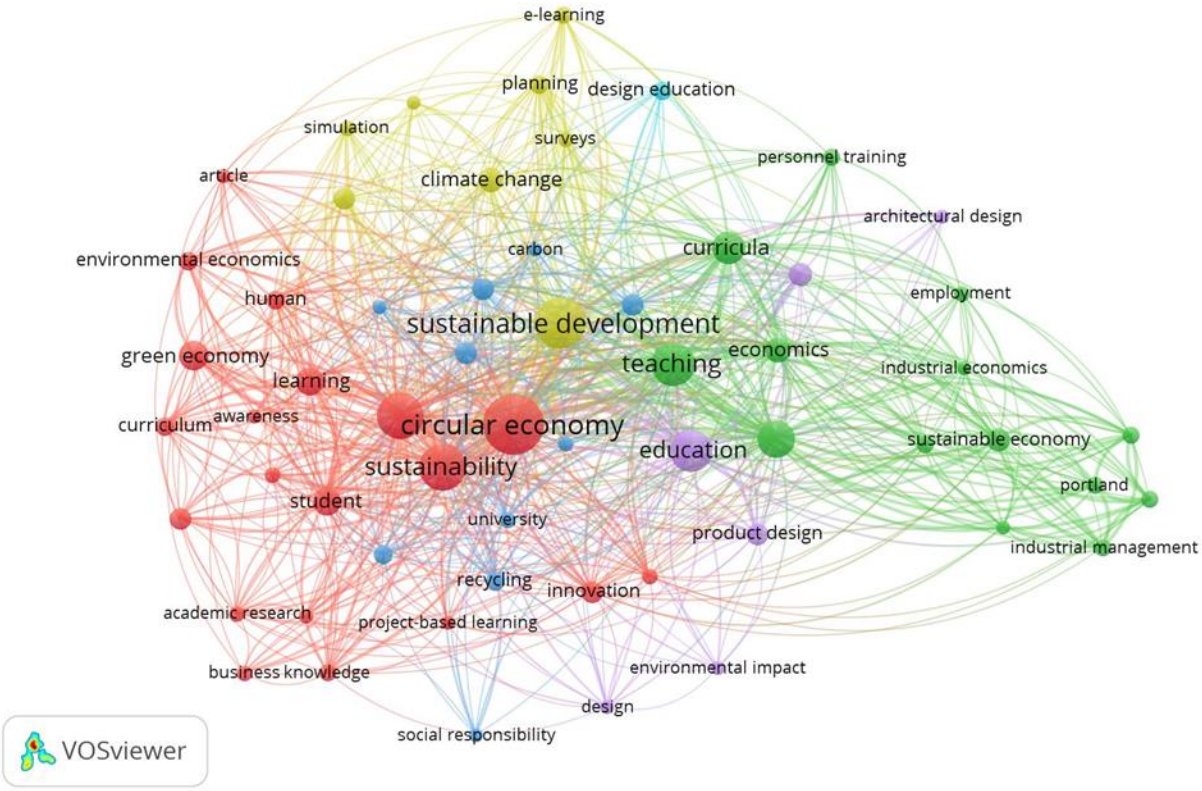

Fig. 5 General Themes of Research on CE Teaching

Based on Figure 5, the first cluster consists of 20 items related to internal areas of higher education institutions, such as: academic research, curriculum, learning, student, project-based learning, and project management. Cluster 2 reflects the wider aspect of how we should teach CE. Nevertheless,

the keywords appearing include education computing, personnel training, teaching, technology, and technology management. Meanwhile, cluster 3 highlights the technical aspects of CE teaching, such as e-learning, planning, simulation, and surveys. The fourth cluster focuses on CE teaching implementation in HEIs and contains the keywords: decision making, HEIs, university, and university sector. Cluster 5 compiles keywords related to more technical design as the output of CE learning CE, including: architectural design, engineering education, environmental impact, and product design. Cluster 6 focuses on 1 keyword: design education.

Three clusters in the data set shows that mostly the publications about the management of formal education for introducing CE for students, including higher education institutions management (cluster one), the technology management (cluster two), and the technical aspects in CE teaching. It implies that most of the time, the HEIs or school managers have accommodated CE in their formal curriculum and the use of digital technology is an essential variable to determine the success in delivering CE materials (Tonelli & Cristoni, 2018). In the formal curriculum, CE is delivered using various method to evaluate the results of their teaching. Whalen et al. (2018) attempted to teach CE using a serious game, a classroom game that de la Torre et al. (2021) developed; while some authors attempted to build instrument for analyzing CE (Ashby & Vakhitova, 2018; Pereira & Frederiksson, 2015) and some designed products (Fleischmann, 2018; Sumter et al., 2018). In the field of vocational schools and academy, Kopnina (2018a, 2018b) analyzed barriers in CE teaching and better strategy to overcome them.

Despite of some success stories in formal CE teaching, some studies found that there are issues should be considered in formal CE teaching. The CE materials taught in class are less contextual (Hens et al., 2018; Kirchherr & Piscicelli, 2019) and inconsistent with the content of knowledge being taught (Fonseca et al., 2018). In addition, the material taught is too complicated, not concrete, and less inclusive (Corvellec et al., 2021). This causes CE education not be able to develop critical, imaginative and innovative thinking about sustainable development (Kopnina, 2018a). Another problem related to classroom learning regarding the circular economy, sustainability, and other relevant matters is that it is difficult to observe changes in student behavior permanently due to the limited number of meetings and monitoring time (Bugallo-Rodríguez & Vega-Marcote, 2020), the need for lecturers who more, the teaching load for lecturers will become heavier, faculty financial management problems related to the increasingly complex activities to be carried out, construction of new facilities, to the difficulty of determining the right evaluation design (Wandl et al., 2019).

The fourth cluster is focused on decision making of HEI for implementing CE and the fifth cluster describes about different disciplines in delivering CE materials. They imply that the university has an important role in designing CE teaching in their institution, including to design it as a multidisciplinary course in HEIs. In the future, multidisciplinary approaches are expected to be more popular in delivering courses on CE. According to Tasdemir & Gazo (2020), transdisciplinary approach is very suitable for use in implementing the concepts of sustainability and sustainable development in higher education due to its flexibility. However, even though multidisciplinary based education has been recognized for its benefits, many universities are still struggling to realize it in their curriculum (Wang & Bart van Bueren, 2018). For instance, in the Master Program at the Faculty of Architecture, University of Delft, The Netherlands, a transdisciplinary course developed under the name "Geodesign for a Circular Economy in Urban Region" or "Geodesign for a Circular Economy in Urban Regions" has been offered in the form of elective courses, but only 15 students are interested. students (Wandl et al., 2019).

The last cluster is design education. The publications in this cluster mostly talked about the alternative in CE teaching. The challenges in CE teaching require a concrete solution than simply improving the existing curriculum design. Mies & Gold (2021) stated that to achieve a comprehensive CE system, a more balanced integration of social sustainability dimensions is required. Education, active community participation and legislative support are the main factors in carrying out the transformation towards a sustainable circular economy. De la Torre et al. (2021) argued that there are other ways to help CE transition in society, namely by promoting the concept of sustainability outside the formal curriculum, and positioning it as a support for business activities. Some publications in the current data set have already started to lead their topic into this focus, such as (Mendoza et al., 2019) who analyzed the practical implementation of CE in HEI and Nadal et al. (2018) who developed

procedures to access the potential of installing rooftop greenhouses in schools as the CE practice outside the classes. It is predicted that in the future, the number of research and publication about implementing CE using informal approach will increase with wider research collaboration across institutions and countries.

Figure 6 shows the evolution of research themes on CE teaching from 2012 to present (2022). The first article on teaching sustainability was published in 1994 entitled "Preparing students to work for sustainability: Teaching as if the earth's future mattered" published in the Journal of Teaching in International Business written by GP Rands from the Department of Management, Pennsylvania State University. This means that 28 years ago the idea on introducing students to circular economy had emerged even if it was with different terms. In this article, Rands (1994) stated that students needed to be prepared to actively contribute to developing sustainable economy by providing them business environment course. This idea developed and 14 years later, in 2008 the idea on sustainable economy teaching as described in some articles was mostly under management discipline, including management education, management for students' competence improvement and SMEs management. The term "Portland" became one of the keywords in this timeline because of an international conference in 2008 named PICMET: Portland International Center for Management of Engineering and Technology with sustainable engineering and technology as one of its topics of discussion.

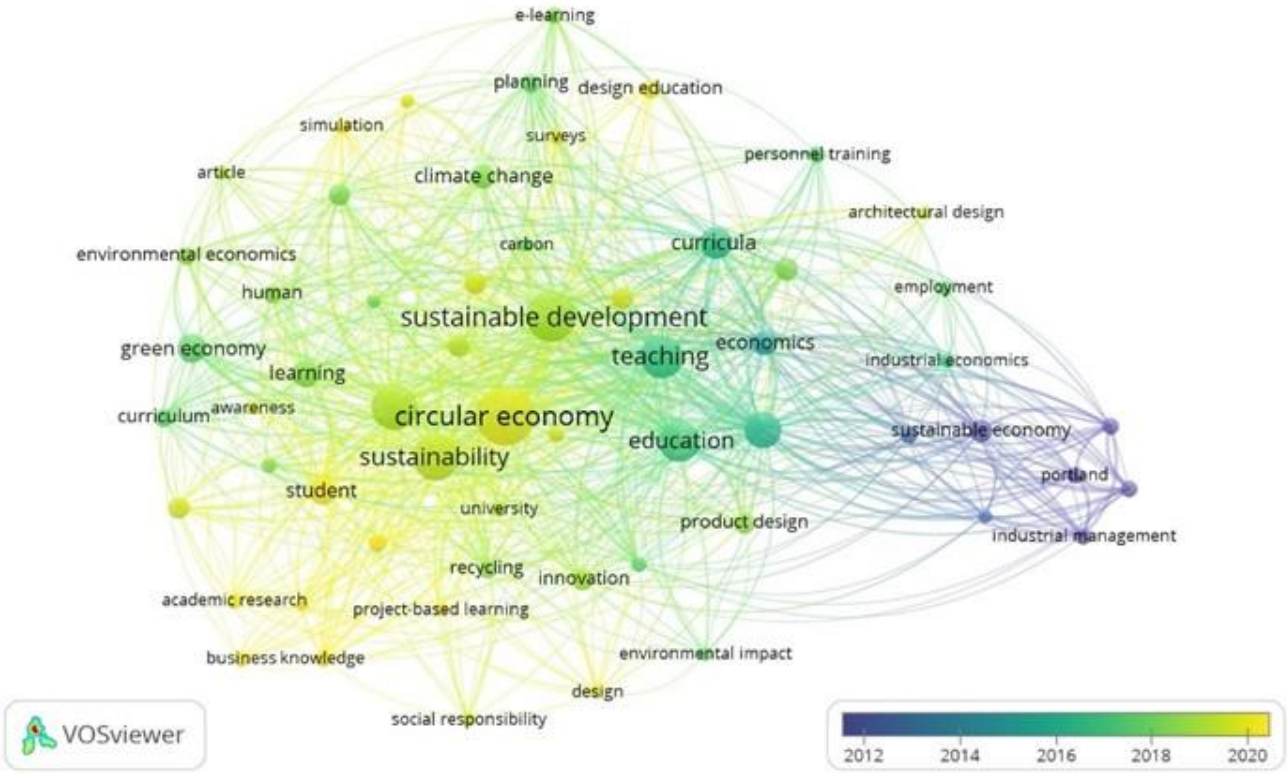

Fig. 6 Evolution of Research Themes in CE Teaching

In 2019 until now, the themes of researches on CE teaching kept developing. Researches on CE teaching in higher education became more popular, especially in Europe. Some authors attempted to find the best practices for changing students' perspective of and attitude towards CE. Wandl et al. (2019) integrated CE values with urban design and planning courses in the Faculty of Architecture, Delft University of Technology, Netherlands; Mendoza et al. (2019) implemented business case along with stakeholders' workshop to put CE thinking into practices for their students in University of Manchester, United Kingdom; Bugallo-Rodríguez & Vega-Marcote (2020) included CE insight into teacher training program at the University of Corunna, Spain; and many other authors attempted various approaches to introduce their students in HEIs to CE.

Despite Europe's domination, recently, studies on CE teaching had spread across the world. From 2020, more countries from different continents published their research results on CE teaching. In Americas, some of them were from the United States (Baeza & Quinn, 2021); Brazil (Cavalcanti-Bandos et al., 2021; Vargas et al., 2020); Colombia (Torres-Guevara et al., 2021); and Croatia (Aver et al., 2021). Meanwhile, in Asia, some contributing authors were from China (Yaoteng & Xin, 2021; Yin et al., 2021); Singapore (Ramakrishna et al., 2020); Thailand (Napathorn, 2021); Oman (Mansour et al., 2020); and Azerbaijan (Mammadov & Vali, 2020). Africa and Australia also had more contribution in research on CE teaching, and some authors were listed in the dataset including Owojori et al. (2022) and Pears (2020)

In the future, it is predicted that the literatures and researches on CE teaching will keep developing the collaborative models between educational institutions and their stakeholders to keep their classroom activities relevant to industrial, environmental and governmental issues. Furthermore, multidisciplinary approaches are expected to be more popular in delivering courses on CE. Basically, the CE materials are pragmatically an integral part of engineering, business or design only, and they should be integrated into solid learning plans. Therefore, courses on CE, especially the basic concepts, should be promoted to general courses that students from any departments in HEIs have access to. After students have taken these general courses, the faculties or departments can develop advanced courses pursuant to their respective fields as follow-up measure. Here, department managers should pay attention to the interdisciplinary approaches in course delivery. For instance, an advanced CE course in a department of engineering should have a proper discussion on industrial, electrical, mechanical, and civil engineering aspects in zero-waste product designing; business school should discuss not only how to develop marketing theory based circular business models but also consider macroeconomics issues, global business trends and strategies to be global market leader; and design students should also learn architecture, anthropology, art and history before creating their eco-friendly design. Finally, the use of digital technology is an essential variable to determine the success in delivering CE materials to students at any educational level and strongly assists practitioners in incorporating CE-oriented product strategies (Tonelli & Cristoni, 2018).

5. Conclusion

Recently, the number of publications on CE teaching is still growing and is predicted not to reach saturation point until the next few decades to come. In business disciplines, CE has so far been implemented into a number of more specific and practical courses. The learning methods used are also varied, mostly based on problem-based learning and project-based learning which are carried out in collaboration with campus stakeholders in order to keep it relevant. The general themes in CE teaching implies that most of the studies that have been published discuss best practices and challenges of CE learning in the classroom. The challenges lead to the rest studies to discuss about how to improve the learning process of CE and found the idea to transform CE courses into multidisciplinary ones to have a more comprehensive point of view to the case study. Furthermore, the studies suggest that CE learning has to be supported by informal education approach. In terms of publication data set, international collaboration for CE teaching needs to be strengthened in order to disseminate the research results.

Hernández-Torrano & Ibrayeva (2020) stated that there is no bibliometric analysis with a perfect picture of the current status and development of a certain field. This study and its findings are included in this very statement. Due to its limited source of search, this study might have excluded some relevant publications and issues. Therefore, future research needs to consider multiple sources of database (e.g., WoS, Google Scholar, or ERIC) for a more representative map of research on CE teaching. In spite of its limitation, this study is believed to provide a comprehensive and relevant review of the literatures on CE teaching, especially in business disciplines.

6. Co-Author Contribution

The authors affirmed that there is no conflict of interest in this article. Conceptualization, I.S.M. and W; methodology, I.M.; software, I.S.M.; validation, W, I.M. and H.W.; formal analysis, H.W.; investigation, I.M.; resources, I.S.M.; data curation, I.S.M.; writing—original draft preparation, I.S.M.;

writing—review and editing, W, I.M. and H.W.; visualization, I.S.M.; supervision, W; project administration, I.S.M.; funding acquisition, I.S.M.

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