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Environmental Literacy Research: Global Scientometric Mapping of Five Decades

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Abstract

To date, there is no scientometric study conducted on Environmental Literacy (EL) literature. Hence, this paper aims to bridge this gap. We aimed fora holistic scientometric analysis of scientific literature available on EL, which resulted in finding global research trends in EL research. We operated the following scientometric tools: VOS viewer and Bibliometrix R Package-Biblioshiny for complete science mapping analysis of the collected bibliographic data retrieved from Scopus database. We analysed the Scopus scientific research outcomes during the last 50 years. The outcome included 438 total documents published and among them 354 were articles and 84 were conference papers published by1112 authors from 50 countries. The findings of this study arevital for policy makers, researchers and other working in environmental education and literacy development to understand the potential gaps and strength in the current EL research in Scopus literature.

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Environmental Literacy; Environmental Education; Research Trends; Scientometric Analysis; Scopus Database.

Introduction

The exponential growth in scientific papers around the world demanded the interpretation and summarization of the research papers on ensuing information in order to assess and analyse its growth, evolution, and progress.[1] Scientometric analysis aims to evaluate scientific productivity of research outputs and also helps in exploring the dynamics of researchers and their research outcomes. Scientometric is a quantitative analysis of visualization of bibliographic data in presenting the research trends including the timeline, production year/ author/ journal/ country/ citation/ institution/ country collaboration/ keyword occurrence etc. several studies dealing with bibliometric elements of research production published in the scientific sources. Scientometric examination of publication output in various countries has been studied in few studies.[2] Citation Analysis is a research approach in informatics that compares the citations of scientific papers, journals,and other research items.[3]

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Environmental literacy is a set of information, feelings, attitudes, abilities, and behaviours relating to the human-environment relationship and environment.[4] EL is broader in its application in various discipline. Teacher preparation at early childhood education is one among the applications where teachers need knowledge, attitude and skills towards effective implementation of EL to students. Like other subjects, EL is one of the paradigms of early childhood teacher education centred on professional development and targeted at gaining action skills from an environmental literacy perspective.[5] Natural resource conservation education, nature education, resource utilisation education, informal education, geography education, and science education all benefit from environmental education, which evolved as a separate field in the mid-1960s. Economic, ecological, social, and political awareness are all goals of environmental education.[6] Environmental literacy refers to people's environmental knowledge, positive environmental values and attitudes, as well as the motivation and skills, and dedication needed to help solve environmental challenges[7]

Increasing environmental literacy at all stages of life will result in a shift in mind-set and subsequent behaviours or actions on the part of individuals, ultimately protecting the entire globe.[8] Cognitive and affective skills, the ability to collaborate with others, the development of communication skills, the understanding of complex information, the analysis and application of such information to new situations, and the acquisition of higher-level skills to develop psychomotor capabilities are all examples of EL skills.[6] Increasing pre-service teachers' environmental literacy and competency so that when they become professional teachers, who can plan and implement active environmental accomplishments in their teaching.[9]

Most reviews suggest the inclusion of El in various disciplines of social sciences and humanities. Like that, science discipline too put effort in promoting Environmental literacy will be addressed primarily in scientific curriculum and text books, perhaps providing opportunities to protect the natural environment and encourage its efficient use[10]. It is necessary to develop kids' environmental literacy. EL is the ability of each individual to take positive action toward the environment in their daily lives by using knowledge about environmental situations.[11] Citizen Science projects, where participants and scientists work on a project together, result in participants communicating about and engaging in field research, and increasing their scientific knowledge and environmental literacy[12] Environmental literacy is essential for students. The formal education system plays an essential role in environmental education activities, particularly at the higher education level, where trans-disciplinary curriculum is available to help university students improve their environmental literacy.[13] And because of their increasing numbers, people play a significant role and have significant influence on the planet. As a result, the demand for food, clean water, fuel, and space grows. Every year, environmental changes will occur in both local and global contexts. As a result, environmental literacy needs to be improved.[14]

Literature Review

Research policy and within the research system, citations are increasingly being employed as performance indicators.[15] We are currently in the midst of a terrible environmental crisis that is not restricted to any one country or region; it is worldwide. The survival of all living species, including humans, has grown increasingly difficult as land, water, and air have gotten increasingly polluted. It is past time to begin a dynamic process of educating youngsters and all residents about today's environmental realities. We need to re-educate ourselves to treat the environment with greater prudence and control, and it is because of this knowledge that environmental education is given top priority.[16]

Environmental literacy is a notion that dates back to the late 1980s and was formalised as a agenda for environmental teaching in the 1990s.[17] The promotion of EL is at the heart of the environmental teaching (ET) movement. Nature study and outdoor education were forerunners to environmental education in the early nineteenth century, but The first worldwide conference on environmental education, sponsored by UNESCO in 1977, drew attention to the area.[18] Environmental literacy is required to develop an environmentally sound society that understands the importance of ecology and environment for human beings' long-term survival.[19] Environmental literacy is developed and nourished through a variety of educational programmes that lead to the development of knowledge, attitudes,

skills, and, eventually, environmental behaviour.[20] Environmental knowledge is the foundation of environmental literacy.[21] It is evident from the above review, no research studies on Environmental Literacy have been conducted using Scientometric analysis. It is also evident that, analysis of burning issues on environmental education related topic will shed light on policy issues to revisit the environmental curriculum.

Objectives of the Study

To analyse the global research productivity in Environmental Literacy Research in terms of Annual scientific productivity, The top contributing authors,The most contributing Journals,The top productive countries, The most cited documents, Visualise the Keyword Co-occurrence Network, The top productive affiliations, The top Country collaboration and to Create a word cloud for Author's Keywords.

Limitations

This study has a few limitations. First, the bibliometric data was collected only from the Scop us database for analysis neglecting other scientific databases like Google Scholar and Web of Science, Thus, other databases may offer a different number of publication data or citation counts. Secondly, due to frequent change in citation volumes over times, the findings of this study are of temporary nature and valid for the time point of the present study's data retrieval on 9th July 2021. This research documents those that are published in English covered the important search do main like Title, Abstract and Keywords etc. that too limited to Journal Articles and Conference papers. However, we believe that this study provides a complete sciento metric out put and advances the insights into the global research on Environmental Literacy.

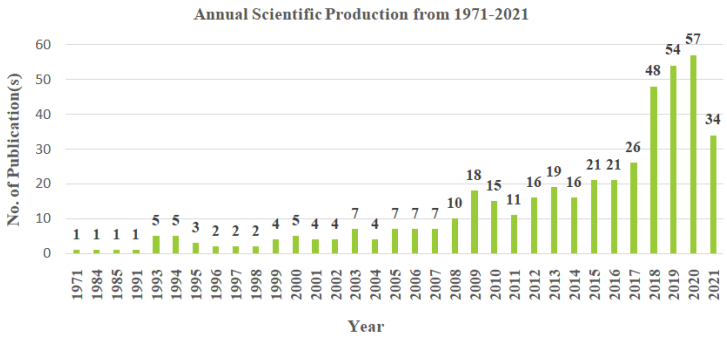

Fig.1: Annual Scientific Production in Environmental Literacy Research

Methods and Materials

All research publications in EL research retrieved from the Scopus Database on July 9th 2021. The search term was ("Environmental Literacy*") in the Title-Abstract- Keywords field and the metadata were collected from 1971 to 2021. The data limited to research articles and conference papers retrieved in English Language. The data were collected 9th July, 2021. The exact output of the search was TITLE-ABS-KEY ("Environmental Literacy*") AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "cp") AND (LIMIT-TO (LANGUAGE, "English") and the same has been analysed accordingly.

The bibliographic data analysis has been carried out with the help of Bibliometrix - An R programme (R version 4.0.2) that allows to conduct extensive quantitative research. It allows bibliographic data to be imported from a variety of sources like data retrieved from Scop us database.[22]

VOS viewer (Version 1.6.16) – is a software tool for mapping and visualizing of scientific network data.

Results

This study looked at the overall increase in EL publications over the last 50 years. 1112 authors published a total of 438 papers, including 222 journals and 216 conference proceedings. Prior to 1993, the total number of scientific publications was quite low (n-4) and began to rise rapidly after 1993, peaking in 2020 (n-57). The average yearly percentage growth rate of annual scientific production increased by 11.65%.

Table 1: Research Outputs in Environmental Literacy

Scopus Data Output In Environmental Literacy	
Timespan	1971 to 2021
Total Documents	438
Average citations per article	10.82
Average citations per year per article	1.243
Total number of References	12829
DOCUMENT CONTENTS	
Keywords Plus (ID)	1335
Author's Keywords (DE)	981
AUTHORS	
Total authors count	1112
Authors of multi-authored articles	1021
Authors of single-authored articles	91
AUTHORS COLLABORATION	
Single-authored articles	98
Documents per Author	0.394
Per-Document Authors	2.54
Per-Document Co-Authors	2.98
Index of Collaboration	3

Figure 1, depicts that the annual number of scientific publications on EL, starting with one in 1971 and ending with 34 in 2021, all of which are already in the Scopus database. From 1971 to July 9th 2021, there has been a steady development and increasein the number of article publications. The increasing growth of publication is seen from 2008 to 2020. Moreover, the year 2020 was the most productive year in terms of highest number of publications in EL with 57 documents.

Citation Rate and Dynamics

The average citation per item (CPI) was 10.82 for the 438 items retrieved and the average citation per year per document was 1.234. The year with the most total citations per article was 60.5, followed by 58.7 in 2007. The average total citation per year in 2007 was a whopping 4.19. The number of single-authored articles has remained constant at 91, while the number of multi-authored articles has increased to 1021.

Table 2: Top Contributing Authors in Environmental Literacy Research

Rank	Authors	Articles	Articles Fractionalized	h-index	g-index	m-index	TC	PY-start
1	GOLDMAN D	10	3.33	8	10	0.5	416	2006
2	YAVETZ B	6	2	5	6	0.313	352	2006
3	MARDIYANTI L	5	0.95	0	0	0	0	2021
4	ORION N	5	1.83	4	5	0.211	128	2003
5	ERDOGAN M	4	2.17	4	4	0.308	96	2009
6	ERTEPINAR H	4	1.17	4	4	0.308	131	2009
7	FANG W-T	4	0.74	4	4	0.571	70	2015
8	PETERSON MN	4	0.71	3	4	0.333	82	2013
9	BOGNER FX	3	1.33	2	3	0.5	13	2018
10	DANIELS CB	3	1	3	3	0.75	28	2018

In the EL research, there were 91 single-authored publications in the whole data set of 1112 authors obtained from Scop us, and 1021 multi-authored publications. Among the top ten contributing authors in the field of EL, Goldman D had the most publications (n = 10) and the highest h-index (n = 8), followed by Yavetz B with the second most publications (n=6) and h-index (n=5). Citation is the most important factor in publishing. Among the top authors listed in table 2, Goldman D had the most citations (n=416), followed by Yavetz B (n=352).

The above data analysis reveals that the top contributing sources/journals were 222 scientific Journal publishing papers in research area of EL. The table 3, reveals that the journal Environmental Education Research had the highest scientific document output (n=31) followed by Journal of Environmental Education (n=26), Sustainability (n=14), International Journal of Environmental and Science Education (n=10) and Applied Environmental Education and Communication (n=8). The top cited journals among the most

productive journals were Journal of Environmental Education (n=1041), followed by Environmental Education Research (n=585) and Journal of Cleaner Production (n=268).

Table 3: Top Contributing Journals In Environmental Literacy Research

Rank	Source	H-Index	G-Index	M-Index	Tc	Np	Py-Start
1	Environmental Education Research	12	23	0.461538	585	31	1996
2	Journal Of Environmental Education	18	26	0.473684	1041	26	1984
3	Sustainability (Switzerland)	5	10	0.714286	109	14	2015
4	International Journal Of Environmental And Science Education	6	10	0.5	100	10	2010
5	Applied Environmental Education And Communication	5	6	0.357143	44	8	2008
6	Eurasia Journal Of Mathematics, Science And Technology Education	4	8	0.307692	87	8	2009
7	International Journal Of Sustainability In Higher Education	5	8	0.238095	110	8	2001
8	Journal Of Cleaner Production	6	6	0.272727	268	6	2000
9	Water (Switzerland)	2	2	1	7	6	2020
10	Journal Of Biological Education	3	5	0.166667	26	5	2004

Table 4: Top Productive Countries in Environmental Literacy Research

Country	Articles	SCP	MCP	Total Citations
USA	78	74	4	1185
INDONESIA	39	38	1	59
CHINA	30	25	5	158
TURKEY	25	19	6	380
ISRAEL	20	19	1	715
AUSTRALIA	16	11	5	137
UNITED KINGDOM	14	13	1	157
MALAYSIA	11	10	1	139
CANADA	10	9	1	41
AUSTRIA	5	2	3	33

Fifty countries were involved in total research output in EL in Scopus Publication. Among them, the top ten countries contributed maximum of publications comparing to other countries (Table 4). The United States of America (USA) published the maximum papers (n=78), had the highest 1185 citations. Other most productive countries were Indonesia (n=39), China (n=30) followed by other countries.The United States of America ranked first in terms of Single Country Publications (SCP) (n=74), followed by Indonesia (n=38), China (n=25) and other countries. In Multi Country Publication (MCP), Turkey ranked first (n=6) followed by China and Australia (n=5) each.

Out of 438 total publications on EL, 50 publications received more citations. Table 5, depicts that the top ten publications as per the total number of citations. The article entitled “Two Avenues for Encouraging Conservation Behaviors by Martha C. Monroe in Research in Human Ecology published in 2003 received the highest citations (n=158) followed by other publications presented in the table5 for comprehensive understanding.

Table 5: Most Cited Papers in Environmental Literacy Research

Rank	Author	Article	Journal	Year	Volume	Issue	Total Citations	TC per Year
1	Martha C. Monroe	Two Avenues for Encouraging Conservation Behaviors	Research in Human Ecology	2003	10	2	158	8.3158
2	Sara Pe'er, Daphne Goldman, B.Yavetz	Environmental Literacy in Teacher Training: Attitudes, Knowledge, and Environmental Behavior of Beginning Students	The Journal of Environmental Education	2007	39	1	146	9.7333
3	Shih-Jang, Hsu.	The Effects of an Environmental Education Program on Responsible Environmental Behavior and Associated Environmental Literacy Variables in Taiwanese College Students	The Journal of Environmental Education	2004	35	2	110	6.1111
4	Robert J. Koester, James Eflin, JohnVann	Greening of the campus: a whole-systems approach Production	Journal of Cleaner	2006	14	11	107	6.6875
5	Negev, Maya; Sagy, Gonen; Garb, Yaakov; Salzberg, Alan; Tal, Alon.	Evaluating the Environmental Literacy of Israeli Elementary and High School Students	The Journal of Environmental Education	2008	39	2	98	7
6	B. B. McBride, C. A. Brewer, A. R. Berkowitz, W. T. Borrie	Environmental literacy, ecological literacy, ecoliteracy: What do we mean and how did we get here?	Ecosphere	2013	4	5	91	10.1111
7	Markus Ruchter, BernhardKlar, Werner Geiger	Comparing the effects of mobile computers and traditional approaches in environmental education	Computers & Education	2010	54	4	85	7.0833
8	Pauline W.U. Chinn	Decolonizing methodologies and indigenous knowledge: The role of culture, place and personal experience in professional development	Journal of Research in Science Teaching	2007	44	9	83	5.5333
9	Yael Kali, Nir Orion, Bat-Sheva Eylon	Effect of knowledge integration activities on students' perception of the earth's crust as a cyclic system	Journal of Research in Science Teaching	2003	40	6	83	4.3684
10	Gaye Tuncer, CerenTekkaya,	Assessing pre-service teachers' environmental	International Journal of	2009			81	6.2308

Semra Sungur, JaleCakiroglu, Hamide Ertepi -nar, Michael Kaplowitz	literacy in Turkey as a mean to develop teacher education programs	Educational Development

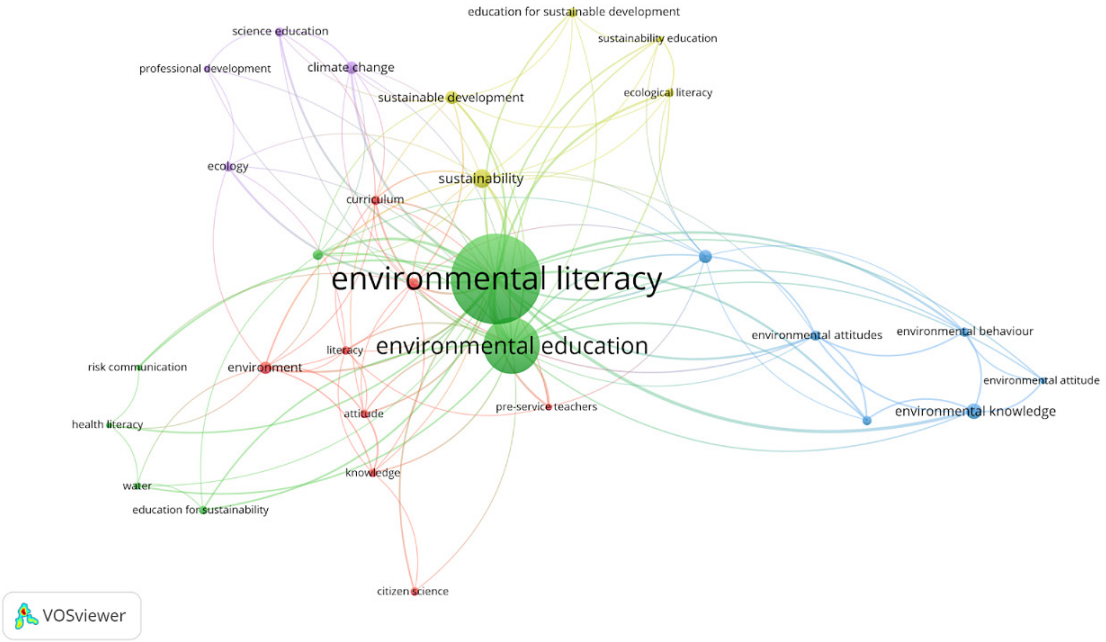

Fig. 2: The Author's keywords co-occurrence network

From the above figure, it is inferred that a total of 1731 author's keywords, only 75 met the criteria of thres hold. The strength of the co-occurrence link ages with other keywords was assessed for each of the 75 keywords. We chose the terms with the most total link strength. The keyword Environmental literacy occurred 153 times with 345 total link strength, Environmental Education occurred 104 times with 293 total link strengths, Literacy occurred 36 times with 204 total link strengths, Students occurred 40 times with 136 total link strengths followed by Article occurred 15 times with 134 total link strengths.

Table 6: Top Productive Affiliations in Environmental Literacy Research

Rank	Affiliations	Country	Articles
1	Universitas Negeri Malang	Indonesia	30
2	Universitas Pendidikan Indonesia	Indonesia	29
3	University Of Otago	New Zealand	27
4	North Carolina State University	Usa	18
5	Middle East Technical University	Turkey	17
6	Ben Gurion University Of The Negev	Isreal	11
7	National Taiwan Normal University	Taiwan	10
8	University Of Southern California	Usa	10
9	Sebelas Maret University	Indonesia	9
10	University Of South Australia	Australia	9

From the above table, it is evident that, a total 435 contributed affiliations, more than 39 affiliations contributed more than 5 publications (Table 6). Among the top ten affiliations first eight affiliations contributed ten or above publications. Three affiliations belong to Indonesia, Univers it as Negeri Malang (n=30) and Univers it as Pendidikan Indonesia (n=29) have contributed the highest documents in EL followed by New Zealand's University of Otago (n=27). Indonesia's three affiliations and The United State of America's two affiliations and each affiliation from Turkey, Israel, Taiwan and Australia were present among the top contributors.

Table 7: Country Collaboration Network In Environmental Literacy Research

Rom	To	Frequency
Usa	Turkey	7
Indonesia	Malaysia	4
China	Thailand	3
China	Usa	3
China	Australia	2
Turkey	Czech Republic	2
Usa	Australia	2
Usa	Iran	2
Usa	Italy	2
Australia	Korea	1

Among 68 Country collaboration network identified in EL research. Table 7, presents top ten country collaboration, among them The United States of America and Turkey collaboration occurred seven times followed by Indonesia and Malaysia – four times. China was the second topper in country collaboration with three countries followed by the United States of America was the most collaborated country among the top ten collaborations with four countries.

Fig. 3: Word Cloud for Author's Keyword

Among 50 Keywords, Authors provided in the all 438 documents, word cloud was formed by measuring the repeated word occurrence in square root for top fifty words in circle shape. The word cloud inferred that, the mostly appeared words like; Environmental Literacy and Environmental Education are treated as the top keywords used by the authors.

Discussion

Scientometrics is the study of assessing the quality and impact of research23. The number of EL related publications have increased 50-fold since the 1971, probably reflecting the different approaches and dimensions of Environmental Literacy (EL) concepts. We deducted an extensive increase in number of publications after 2007. The analysis forecasts that EL research is in increasing trend since there has been a steady increase in number of publications since 1971.

The Multi-authored publications have a higher trend than of the single-authored publications. The United Kingdom had the top two ranked journals: Environmental Education Research (3.512 impact factor (IF) and 5.2 Cite-Score as per 2020, the most contributed journal in EL) followed by another United Kingdom based journal The Journal of Environmental Education publishes pedagogical research in sustain

ability and environmental education, (2.915 IF and 4.2 Cite-Score as per 2020.)

The supportive policy, funding and research outlook policy in USA placed the in the top among 78 articles in which 74 SCP and receive the highest 1185 citations. The larger the influence, the more often is cited. Because of its pioneering contribution, high-citation literature is frequently regarded as a landmark in this academic field.[3]

Since the study collected bibliographical data on ELand it is highly associated with the key term Environmental Education, keyword co-occurrence network reveals that the most of the authors in EL research papers used Environmental Literacy (n=153) or Environmental Education (n=104) as the predominant keyword in their papers. Three affiliations from Indonesia and two affiliations from the USA were among the top productive affiliations in EL research.

Country collaboration is a noted parameter in research output of any discipline. In El research the association between the USA and Turkey found to be the highest.

The study results shall be of great support to the Stake holders in order to know the research trends or pattern on a specific key terms and publications in Environmental Literacy. The stake holders like funding agency may fund more on the most needed researched areas. The researchers, may identify the research gap of the research areas and fill the gap by conducting research. The teachers, may give more concentration on the recent research findings in their teaching. The students may take up specializations which are the need of the hour.

Conclusion

Increased attention to environment and environmental issues inevitably brings rising expectations for solutions to critical problems through research-based evidence. Empirical research has always evolved from academic disciplines that draw from the oretical and empirical foundations. Hence, research and number of publications on environmental literacy (EL) have been published over a five decades has been evaluated using Sciento metric analysis. The purpose of this research was to portray a comprehensive and systematic scientometric analysis of environmental literacy esearch in the global scenario. This study is the first of its kind to investigate global EL research trends that provides in-depth analysis and information into the annual scientific productivity, top contributed authors, most contributed journals, top productive countries, globally most cited documents, Co-occurrence Network of Keyword, top productive affiliations, top Country collaboration network finally word cloud for Author's Keywords, emphasizing the different dimensions of EL research approaches. Over the past five decades, research in Environmental literacy has progressed tremendously, resulting in a greater awareness of fundamental Environmental issues from regional, national and international levels. EL is important because it plays a crucial role leading to advancement in the emerging areas like sustainable development, environmental attitude, awareness and behaviour, education for sustainability, eco-friendly practices, pro-environmental behaviour, environmental knowledge and health literacy.

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Conflict of Interest

All the authors declare no conflict of interest.

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