Research Synthesis in Pro-environmental Behaviour in Education: A Text Mining Approach

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There have been many academic investigations on promoting human behaviour in favour of environmental sustainability though education. Yet only a limited number of review papers are found which have summarized the key findings of this vital area. This study uses both bibliometric and text mining approaches to examine pro-environmental behaviour in education literature for the first time. Through bibliometric analysis, different networks in contemporary literature are highlighted. These networks reveal the influence of social welfare on pro-environmental behaviour, highlighting the value of human innate connection to raise environmental consciousness. Additionally, using posterior probability and Latent Dirichlet allocation (LDA), text mining identifies 12 different topic models by log-likelihood estimation, addressing a variety of topics related to environmental education and behaviour, such as how visitors and sustainability in environmental education affect pro-environmental behaviour, how education towards sustainability is provided in schools and universities, how the theory of planned behaviour is applied, how education and pro-environmental behaviour are related, and how sustainable education

and travel are explored through different channels.

Keywords: pro-environmental behaviour, education, text mining, bibliometric analysis
JEL Classification: I20, I24, I25

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Introduction

Environmental behaviour is defined as efforts taken to protect the environment, often known as green, sustainable, or eco-friendly conduct. This can involve things like interacting with nature sustainably or reusing domestic waste. Choosing sustainable products like organic food and eco-friendly cleaning supplies, conserving energy and water, switching to sustainable modes of transportation like walking and cycling, embracing electric vehicles, and even building off-grid homes are all part of embracing sustainability (Vicente-Molina, Fernández-Sáinz, and Izagirre-Olaizola 2013). Various issues, like global warming, urban air pollution, water scarcity, loud noises, and habitat destruction are all threats to environmental preservation. Most of these problems are caused by humans (Schüßler, Richter, and Mantilla-Contreras 2019). This has become a significant concern in today's world, and everyone should be aware of it (Valkengoed, Abrahamse, and Steg 2022). Education is the most efficient means of informing people about the value of pro-environmental action, making it one of the most effective strategies. Education for lifelong learning is not only a means of informing people but also a tool for raising their awareness. Education can also demonstrate its potential to promote environmentally conscious decision-making.

Education is crucial in influencing human behaviour toward the environment to make the future world more attractive, healthier, and worth living in. Environmental education that promotes sustainable development will help to protect natural systems while also fulfilling human aims (Chankrajang and Muttarak 2017). Several studies have already examined the pro-environmental behaviour. However, a detailed theoretical assessment of the articles on this issue is yet to be completed as far as we know. As a result, a thorough literature review is a valuable tool to make individuals more concerned about their behaviour towards the environment. This review contributes to a more knowledgeable and successful approach to behaviour modification.

The Scopus database has generated many papers on pro-environmental behaviour through education during the last 25 years. In the first step of the investigation, a citation mapping approach known as bibliometric analysis is used to assess the entire list of documents connected to the literature. The findings of this bibliometric analysis demonstrate the importance of this research issue in determining the value of environmental education. This study's bibliometric analysis included the co-occurrence network and bibliometric coupling on 608 papers, yielding new research directions for the future. However, the text mining technique is utilized on a selected 34 publications to cover as many documents on pro-environmental behaviour as possible with a careful review.

The study's reasoning is based on the identification of a discrepancy between the growing call for sustainable practices and the pervasive negative environmental effects of unrestrained consumerism. This disagreement highlights how critical it is to address environmental issues by reducing consumption and changing public perceptions of the environment. The study's primary objective is to provide a comprehensive assessment of the literature on environmental education and pro-environmental behaviour using state-of-the-art analysis tools. It aims to identify key themes, connections, and gaps in the research landscape in the context of global environmental concerns and consumerism in order to advance our knowledge of how education may promote pro-environmental behaviour.

The remaining part of the paper is divided into five parts. The second section contains the methodological elements and a summary of the text mining, bibliometric analysis, and trend analysis processes employed in this work. The third section explains references network analysis, and trend analysis of the environmental education literature. The advanced review is demonstrated in the fourth section, which includes the text mining approach, results, discoveries, and a description followed by implications, conclusion and research limitations in the fourth and the fifth section.

Methodology

For bibliometric review, this paper presents reference network analysis, which shows the visual evaluation of repetition of author keywords per document, co-authorship of countries, and citation relevancy per document. After that, topic tracking of the documents was done with the help of Latent Dirichlet Allocation (LDA) (Kaushik and Naithani 2016). Apart from these, a trend analysis is also introduced to represent the journal trend of the documents.

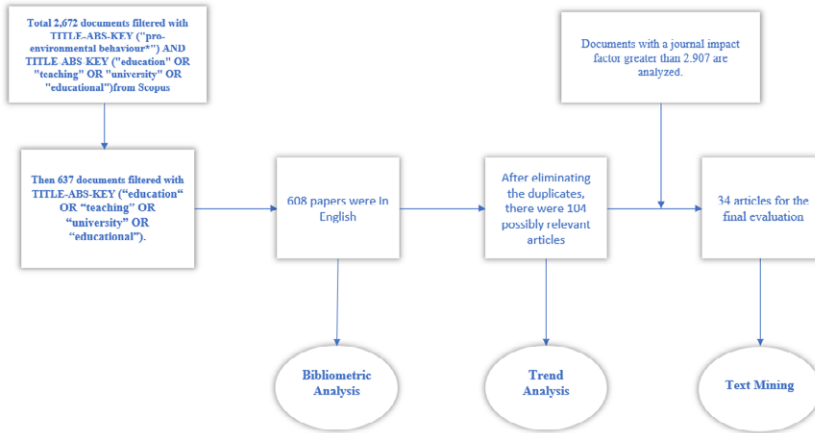

FIGURE 1 Selection of Papers

By using the following options applied to the title, abstract, and keywords: TITLE-ABS-KEY ('pro-environmental behaviour*') AND TITLE-ABS-KEY ('education' OR 'teaching' OR 'university' OR 'educational') a selection of published papers on pro-environmental behaviour in education was gathered from the online database of Scopus. Since Scopus database provided the maximum number of documents, which is much more than the WOS database, and the software used in this paper does not support WOS data, this study decided to continue with the Scopus database. Afterward, only English-language articles were chosen, totalling 623 papers, and only 608 papers were found as possessing materials within the topic range for the bibliometric review after manual examination by the researchers. After deleting the duplicates, 104 eligible papers for trend analysis were found. Only 34 papers were selected manually for text mining premised on journal impact factor higher than 2,907. Figure 1 depicts the selection procedure of the articles.

This review study follows four parts for examining the selected studies: the source of the documents, the techniques used to analyse the documents, the indicators utilized in the procedures, and the analysis outcome. The source of the documents is Scopus database. VOSviewer is used to create Bibliometric Networks, including bibliographic coupling analysis and co-occurrence networks. The outcome indicates author keyword relevance and a full citation summary of each article. The R-tool for Text Mining, which is the primary emphasis of this article, is utilized to perform Trend Analysis and Latent Dirichlet Analysis. The outcome demonstrates good attitudes toward pro-environmental behaviour in ed-

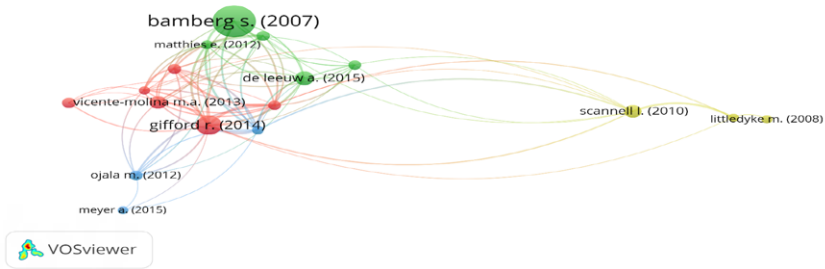

FIGURE 2 Bibliographic Coupling Analysis of Documents

ucation, as well as the construction of subject models with appropriate topic phrases per article.

Analysis

REFERENCES NETWORK ANALYSIS

Bibliographic Coupling Analysis of Documents

Bibliographic coupling is a similarity measure that uses citation analysis to build a similarity link between documents. A document-based bibliometric coupling study is shown in figure 2. Only 15 papers out of 608 meet the criterion when the minimal number of local citations is 115. After the bibliographic coupling, 20 nodes were separated into 4 clusters. The node's size indicates the number of times the papers have been mentioned. Red, green, blue and yellow are, respectively, the 4 clusters available here.

The Red cluster (cluster 1) mainly focuses on environmental knowledge and behaviour. There are seven nodes in this cluster. Gifford and Nilsson (2014) set out to count the influences on pro-environmental concerns, which are grouped into 18 personal and social factors.

The Green cluster (cluster 2) which consists of 4 nodes, focuses on environmental awareness. Bamberg and Möser (2007) assert that problem awareness is a significant but unreliable indicator of pro-environmental intention. Its effects appear to be moderated by guilt, attributional processes, and moral and social norms.

The Blue cluster (cluster 3) emphasizes influences and factors like social welfare and ecology-aiding PEV (Pro-Environmental Behaviour). This cluster consists of 3 nodes. According to Meyer (2015), education makes people more concerned with social welfare and thus more ecologically conscious.

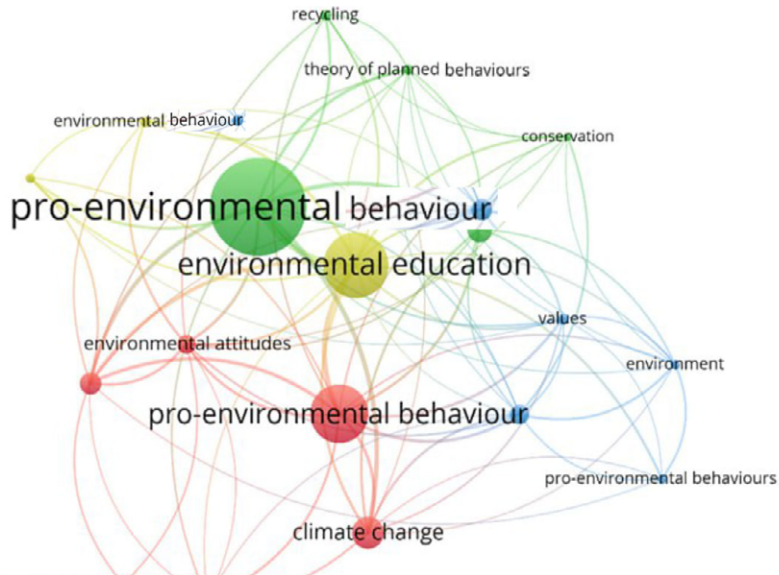

FIGURE 3 Co-occurrence Network of Author Keywords

The Yellow cluster (cluster 4) mainly talks about pro-environmental behaviour and social identity. Scannell and Gifford (2010) discovered that when the neighbourhood, length of residency, gender, educational level, and age were considered, only a person's natural connection to a place was found to predict pro-environmental behaviour.

Co-occurrence Network of Author Keywords

Co-occurrence network analysis is a set of graphs that show the possible connections between ideas, institutions, people and other elements in texts. Figure 3 shows the co-occurrence network of author keywords, which displays terms used by writers in similar but not identical texts and about the same subject. When the minimum number of occurrences for a keyword is 11, 18 out of 1,645 keywords pass the test. Each node represents a list of terms used by the writers. The pro-environmental behaviour through education co-occurrence network has 14 nodes in four clusters, with 46 linkages and 142 link strengths.

TREND ANALYSIS

Table 1 shows a trend analysis of the top 15 journals with the highest impact factor in encouraging pro-environmental behaviour through education.

TABLE 1 Trend Analysis of Journal

Element	h_ index	g_ index	m_ index	TC	%	Trend	NP	%	Cor. Doc	%	PY_ start
Building and Environment	1	1	0.08	11	0.14	↰	1	0.58	1	0.005	2009
Ecological Economics	4	5	0.6	214	2.81	↑	5	2.91	5	0.02	2015
Energy Policy	2	2	0.2	18	0.24	↰	2	1.16	3	0.01	2012
Environmental Education Research	21	41	0.95	1724	22.61	↰	52	30.23	32	0.16	2000
Environmental Research Letters	1	1	0.5	4	0.05	↰	1	0.58	4	0.02	2020
Environmental Science and Pollution Research	2	2	0.4	21	0.28	→	2	1.16	5	0.02	2017
International Journal of Environmental Research and Public Health	3	6	0.5	107	1.40	↰	6	3.49	10	0.05	2016
Journal of Cleaner Production	16	22	1.78	1165	15.28	↰	22	12.79	31	0.15	2013
Journal of Environmental Management	3	3	0.3	24	0.31	↰	3	1.74	6	0.03	2013
Journal of Environmental Psychology	14	19	0.93	3363	44.10	↰	19	11.05	15	0.07	2007
Nutrients	1	1	0.25	35	0.46	↑	1	0.58	1	0.005	2018
Resources, Conservation and Recycling	6	6	0.6	336	4.41	↰	6	3.49	8	0.04	2012
Sustainability (Switzerland)	14	19	1.56	488	6.40	↑	44	25.58	69	0.34	2013
Sustainable Development	2	2	0.2	11	0.14	↑	2	1.16	1	0.005	2012
Waste Management	4	6	0.3	104	1.36	↑	6	3.49	12	0.06	2011

Because a single publication might contain many citations, the total citations add up to 7,625. There are 172 publications in total, with 203 corresponding documents. The percentages of these are calculated based on the total number. The biblioshiny in R tool is used to calculate the h-index, m-index, and g-index. The evolution of the last five years (2017–2021) was examined to measure trends in citation numbers. The slope in the number of citations per year was used in this case (Dominković et al. 2021). For instance, the slope is $\{(5-1)/(2021-2017)\} = 1$ if one journal has citation number one in 2017, two in 2018, three in 2019, four in 2020, and five in 2021. Five ranges of trends were added after establishing the publishing development (slope) for all authors, providing four ranges of positive and negative trends and one range for a constant citing number

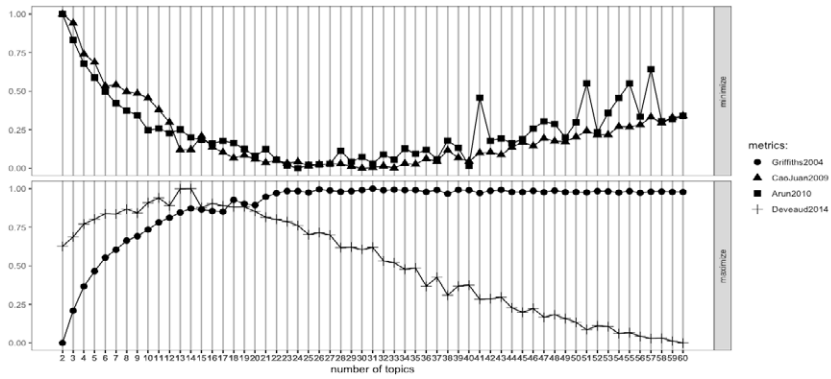

FIGURE 4 Log-Likelihood and Perplexity Metrics to Evaluate *K*

NOTES ● Griffiths and Steyvers (2004); ▲Cao et al. (2009); ▪ Arun et al. (2010); + Deveaud, SanJuan, and Bellot (2014)

(i.e. slope = 0.0). For the ranges the arrows indicating the trend are: For range (≥25) arrow (↑), range (1-24) arrow (↰), range (0) arrow (→), range ((−1)-(−24)) arrow (↲), and range (≤−25) arrow (↓).

Research Synthesis with Text Mining

LDA ANALYSIS

One of the most powerful text mining approaches for data analysis, latent data exploration, and finding links between data and text documents is topic modelling. Topic modelling can be done in a variety of ways, but the most common one utilized in this study was Latent Dirichlet Allocation (Jelodar et al. 2019). Latent Dirichlet Allocation (LDA) is the major topic of this study. The number of latent themes was calculated using the log-likelihood and perplexity of the data (Arun et al. 2010; Cao et al. 2009; Griffiths and Steyvers 2004). Perplexity is a measure that shows whether 'the model predicts the remaining words in a given subject after witnessing a portion of it, whereas log-likelihood evaluates how well the latent topics represent the observed data' (Guerreiro, Rita, and Trigueiros 2016). Figure 4 shows the range of possible themes investigated in this study, which ranged from $K = 2$ to $K = 60$.

In the figure, Griffiths and Steyvers (2004) show a sharp rise after 20 topics, which suggests that the model is picking up increasingly detailed and distinct themes in the data as the number of subjects rises. The plateau at about 20 topics indicates that adding more topics does not improve the model's capacity to detect more significant patterns after a certain point. Given that Deveaud, SanJuan, and Bellot (2014) continuously

decreases after 20 subjects, it is possible that the model or methodology employed there needs to be clearer to distinguish between coherent and significant themes after that. It can indicate that as the number of subjects rises, the data gets smoother and clearer, which makes it more difficult for the algorithm to identify different themes accurately. The results of the models show that the measure has a first inflexion on $K = 12$ in both the minimize and maximize version, hence this paper used $K = 12$ to evaluate the groups, assuming that the variance reported has a first inflexion and that the explanation is based on a small cluster. This log-likelihood was generated using the R-tool.

The corpus is then analysed with R packages (tm, topicmodels, LDAvis, stringr, and stringi) to determine the posterior probability and word frequency in each document. $K = 12$, *alpha* = 1, *eta* = 0.001, and *iterations* = 10 were utilized, with K denoting the topic model number and the rest denoting functionality parameters. There are 12 different topic models created, each with its own set of terminology. The subject terms are the most commonly used words in each text, which are grouped into topic models based on their significance (Ramage et al. 2009). With the help of LDA, the 34 documents are assigned to these 12 topic models based on their posterior probability.

TEXT MINING EXPERIMENTS, RESULT, AND ANALYSIS

The variables for LDA functionality are selected. The functions of the chosen parameters are $K = 12$, *alpha* = 1, *eta* = 0.001, and *iterations* = 10. The commands for generating topic models and distributing co-related terms to the topic models are provided with the aid of R. The computer runs the commands, selects the most frequently used phrases, and distributes them across the 12 topic models ($K = 12$) according to relevance. Each topic model has a maximum of 12 co-related words (lda fit. terms [1:12,]). The frequency of subject phrases in each document's topic model is depicted in figure 5.

During the generation of the topic models, R programming commands for determining the posterior probability of each article for each topic model using the same parameters are provided. The R software ran for roughly an hour for the papers and provided a correct posterior probability result. The names of the topic models are determined by the terms they cover. Table 2 shows the linked documents of the topic models created by manually selecting the journal, impact factor, paper type, and affiliations.

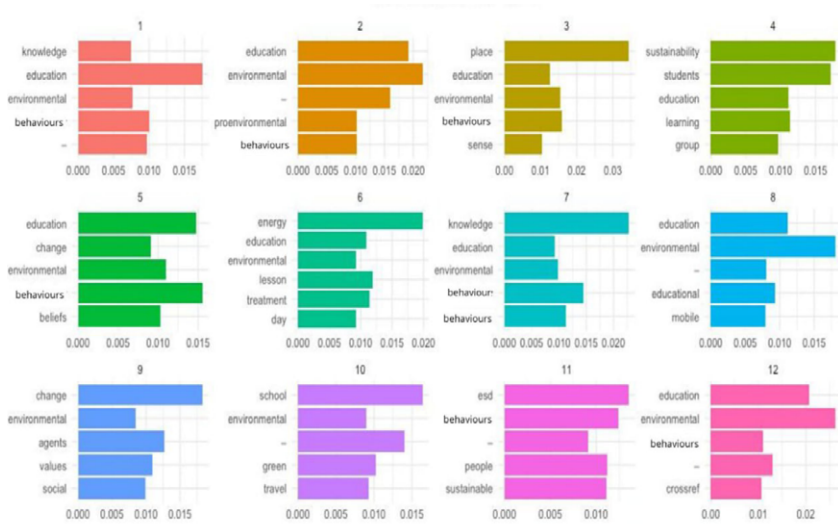

FIGURE 5 Topic Term Frequency Allocated to Topic Models

Table 2 shows the LDA result of topic modelling with 12 topics discussing each topic, with at least two documents per topic.

Topic 1, 'Visitor impact on behaviour', deals with the papers expressing the influence of visitors on behaviour and education. Dodds and Holmes (2018) (posterior probability = 0.18) examine three primary hypotheses about how visitor categories differ in knowledge, social standards, accreditation, and beach satisfaction based on past research. Residents and older beachgoers were shown to be more likely to participate in environmental education initiatives, according to their research.

Topic 2, 'Sustainability in environmental education', discusses the documents concerning having a proper sense of and maintaining sustainability in environmental behaviour. From an ecological standpoint, Kudryavtsev, Stedman, and Krasny (2012) (posterior probability = 0.25) contribute to environmental behaviour studies on the sense of community. They discuss many aspects of place sense, such as place connection and meanings. The logic and evidence supporting a relationship between connectivity, place interpretations, pro-environmental behaviour, and elements influencing sense of community are next reviewed. Schaal and Lude (2015) (posterior probability = 0.16) want to figure out what these devices could be used for, as well as what hurdles they might face.

TABLE 2 Latent Topics

Topic Name	Topic Terms	Correlated Papers	Posterior probability	Journal (Impac t Factor)	Method of Study
Visitor impact on behaviour	Age, behaviour, education, children, educational, environmental, knowledge, learning, pro-environmental, results	Dietz, Mulford, and Case (2009)	0.22	Building and Environment (6.456)	Qualitative
		Dodds and Holmes (2018)	0.18	Ocean and Coastal Management (3.284)	Qualitative
Sustainability in environmental education	Actions, behaviour, education, environmental, change, concern, knowledge, pro-environmental, schooling, willingness, years	Kudryavtsev, Stedman, and Krasny (2012)	0.25	Environmental Education Research (3.512)	Quantitative
		Schaal and Lude (2015)	0.16	Sustainability (3.251)	Mixed method
Impact on pro-environmental behaviour	Attachment, behaviour, education, environmental, gamification, place, pro-environmental, meanings, sense, social	Sánchez-Maroño et al. (2015)	0.16	Neural Processing Letters (2.908)	Qualitative
		Begum et al. (2021)	0.18	International Journal of Environmental Research and Public Health (3.39)	Quantitative
		Wang et al. (2021)	0.11	Sustainability (3.251)	Qualitative
Environmental education through organization	Activities, education, educational, group, learning, online, students, sustainability, sustainable, travel	Cole and Altenburger (2019)	0.16	Environmental Education Research (3.512)	Qualitative
		Pérez-López et al. (2020)	0.12	Frontiers in Psychology (2.99)	Mixed method
		Neaman, Otto, and Vinokur (2018)	0.15	Sustainability (3.251)	Qualitative
		Esteban Ibáñez et al. (2020)	0.16	Sustainability (3.251)	Qualitative
		Määttä and Uusiautti (2020)	0.11	Sustainability (3.251)	Quantitative
Sustainable responsibility	Behaviour, beliefs, change, climate, control, education, effects, environmental, norms, pro-environmen tal	Winter and Cotton (2012)	0.15	Environmental Education Research (3.512)	Quantitative
		Manfredi et al. (2021)	0.13	Sustainability (3.251)	Quantitative
		Nursey-Bray et al. (2019)	0.11	Sustainability (3.251)	Qualitative
Education towards sustainability of environmental behaviour	Conservation, energy, education, environmental, day, electricity, households, lesson, school, treatment, use	Sarid and Goldman (2021)	0.19	Sustainability (3.251)	Qualitative
		Gomera et al. (2021)	0.11	Sustainability (3.251)	Qualitative
		Zelenika et al. (2018)	0.14	Environmental Education Research (3.512)	Quantitative

Continued on the next page

TABLE 2 *Continued from the previous page*

Topic Name	Topic Terms	Correlated Papers	Posterior probability	Journal (Impac t Factor)	Method of Study
Sustainable implications for educational interventions	Attitude, behaviour, environmental, education, food, knowledge, pro-environmental, sustainable, social, waste	Mahmud, Husnin, and Soh (2020)	0.25	Sustainability (3.251)	Qualitative
		Grund and Brock (2019)	0.18	Sustainability (3.251)	Qualitative
Pro-Environmental behaviour with planned behaviour	Activities, devices, environmental, education, learning, mobile, nature, program, sustainability, university	Grund and Brock (2020)	0.20	Sustainability (3.251)	Quantitative
		Leeuw et al. (2015)	0.15	Journal of Environmental Psychology (5.192)	Qualitative
Educational approaches for environmental education	Agents, agency, change, different, environmental, framework, model, social, sustainability, values	Ouariachi, Li, and Elving (2020)	0.13	Sustainability (3.251)	Quantitative
		Schüßler, Richter, and Mantilla-Contreras (2019)	0.17	Sustainability (3.251)	Quantitative
Education and pro environmental behaviour	Behaviour, building, change, education, environmental, school, green, participants, school, students, sustainability, travel	Chankrajang and Muttarak (2017)	0.23	Ecological Economics (5.389)	Qualitative
		Hoffmann and Muttarak (2020)	0.12	Environmental Research Letters (6.793)	Quantitative
		Payne (2002)	0.16	Environmental Education Research (3.512)	Quantitative
		Meyer (2015)	0.18	Ecological Economics (5.389)	Quantitative
		Suárez-Perales et al. (2021)	0.13	Journal of Cleaner Production (9.297)	Quantitative
Sustainable education and travel	Behaviour, education, future, hope, people, positive, sustainability, young	Gill and Lang (2018)	0.20	Energy Policy (6.142)	Quantitative
		Hale (2019)	0.17	Sustainability (3.251)	Quantitative
Exploring environmental education through different channels	Behaviour, education, environmental, empowerment pro-environmental, psychological, religiosity, students	Cavaliere, De Marchi, and Banterle (2018)	0.15	Nutrients (5.717)	Quantitative
		Collins et al. (2020)	0.22	Environmental Education Research (3.512)	Qualitative
		Redman and Redman (2014)	0.15	Journal of Cleaner Production (9.297)	Quantitative

Topic 3, 'Impact on pro-environmental behaviour', examines the influence of organizational, moral, and science-based education on pro-environmental behaviour in diverse ways. Sánchez-Maroño et al. (2015) (posterior probability = 0.16) presented the organizational education on environmental behaviour using a decision-making model for the agents based on the organization's response data. Using conservation of resource theory concepts, Begum et al. (2021) (posterior probability = 0.18) explored the link between environmental moral education and pro-environmental conduct. In this link, the mediating effect of psychological empowerment and the moderating effect of religion were studied.

Topic 4, 'Environmental education through organization', discusses the teaching orientation towards environmental behaviour within school, college or university education. Cole and Altenburger (2019) (posterior probability = 0.16) look at three case studies from across the United States on Teaching Green Buildings. Pérez-López et al. (2020)as outdoor contexts, might contribute to the development of students' affective relations toward nature, proenvironmental attitudes, and protective actions; neverthless, these aspects begging to be explored. This preliminary research investigates the impact that the use of organic gardens to teach natural sciences at university has on kindergarten pre-service teachers' KPST (posterior probability = 0.12) look into the impact of using organic gardens to teach natural sciences at university on kindergarten pre-service teachers' sense of connection to and ideas of nature.

Topic 5, 'Sustainable responsibility', deals with the sense of responsibility towards pro-environmental behaviour to maintain sustainability. Winter and Cotton (2012) (posterior probability = 0.15) used a phono myographic technique to explore students' views of a 'hidden sustainability curriculum' at a top sustainability university in order to increase students' environmental responsibility. Researchers used a linear pre-test and post-test experimental design in a study by Manfredi et al. (2021) (posterior probability = 0.13), to investigate whether two co-designed interventions, a garbage and recycling bin system and a materials exchange programme, could improve sustainability literacy and material conservation behaviours throughout the School of Design.

Topic 6, 'Education towards sustainability of environmental behaviour', discusses educating people about sustainability development. Intending to generate competent environmental citizens, Sarid and Goldman (2021) (posterior probability = 0.19) aspire to improve theoretical understanding of what motivates people to act as change agents, as well

as the type and degree of change they wish to see. The overall goal of Gomera et al. (2021) (posterior probability = 0.11) is to provide a realistic atmosphere for involvement, communication, motivation, and competence, which are all necessary for effective pro-environmental conduct. Those who engaged in the Field School programme were compared to the garden visitors who did not participate in the Field School programme. Zelenika et al. (2018) (posterior probability = 0.14) revealed that participants' awareness of environmental issues, sense of connection to nature, and intentions and desire to participate in sustainability all rose after the programme's activities.

Topic 7, 'Sustainable implications for educational interventions', deals with teaching staffs' ability for implying sustainability in educational interventions. The goal of Mahmud et al. (2020) (posterior probability = 0.25) was to look into the impact of teaching presence in online gamification on long-term learning and self-determination and determine the elements that drive and hinder students' engagement in online gamified activities. The modest expectation of favourable socio-ecological changes may deter half of the sample from acting more sustainably, showing significant room for optimism. The consequences for Sustainable Development Education are highlighted in Grund and Brock (2019) (posterior probability = 0.18).

Topic 8, 'Pro-Environmental behaviour with planned behaviour', discusses the application of the theory in environmental behaviour. The goal of Grund and Brock (2020) (posterior probability = 0.20) aims to forecast long-term behaviour based on reported Educational Sustainable Development implementation, as well as psychological (e.g. attitudes, emotions) and socio-demographic factors. The theory of planned behaviour was used by de Leeuw et al. (2015) (posterior probability = 0.15) to uncover the ideas that impact young people's pro-environmental conduct. High school students completed a questionnaire regarding their pro-environmental behaviour early in the academic year and reported on their behaviour at the end of the year.

Topic 9, 'Educational approaches for environmental education', discusses taking approaches through education for environmental behaviour. Ouariachi, Li, and Elving (2020) (posterior probability = 0.13) aim to look into the function of gamification in influencing pro-environmental behaviour change and to find the best activities for educational reasons. Environmental education (EE) can be a valuable tool for biodiversity conservation, but implementation in low-income nations is complex.

Topic 10, 'Education and pro environmental behaviour', discusses green returns to education. According to Chankrajang and Muttarak (2017) (posterior probability = 0.23), more years of education increase the likelihood of undertaking knowledge-based environmentally beneficial actions, but not cost-effective pro-environmental behaviours. There is little evidence that formal education has a significant influence on global warming concerns or willingness to pay a carbon price. Suárez-Perales et al. (2021) (posterior probability = 0.13) validate higher environmental management education's emancipatory approach over its instrumental counterpart.

Topic 11, 'Sustainable education and travel', talks about how recycling, water conservation, and energy conservation are among the topics covered in environmental education for school pupils. According to Gill and Lang (2018) (posterior probability = 0.20), energy education may be a useful tool for policymakers interested in energy efficiency, while further research is required to improve the scheduling and subject matter of such presentations. Furthermore, Hale (2019) (posterior probability = 0.17) pushes educational travel givers (institutions, employees, and academics) to help their host communities by emphasizing the need for a broader understanding of sustainability in educational travel programmes.

Topic 12, 'Exploring environmental education through different channels', mainly discusses how different behaviours interact with the knowledge domains to differing degrees. Collins et al. (2020) (posterior probability = 0.22) show that learning lasts a lifetime, but that education can be improved with lengthier sessions. Educators can empower the future generation to make personal changes based on their future vision and make the demand on structural and organisational reforms required for a successful transformation to sustainability (Redman and Redman 2014) (posterior probability = 0.15).

Implications and Future Research Directions

The current study's findings point in the right direction for this study's purpose. The posterior probability for 12 latent subjects is estimated here, allowing future surveys on any of these topics to be done in a way that attracts researchers' attention. The articles on topic 2 (sustainability in environmental education) and topic 7 (sustainable implications for educational interventions) have the highest posterior probability compared to the other ones, indicating that these two themes have a good chance of being picked for further research. Researchers can focus on

developing sustainability in pro-environmental behaviour and make people aware of that. They can express the idea of the implication of sustainability through their future research.

Findings from trend topics and bibliometric analysis prove the relevance with the objective of this paper, which is pro-environmental behaviour through education. From these, the role of male and female students in pro-environmental behaviour can be an exciting topic for future research. Researchers can portray how the differing groups of male and female students affects environmental behaviour. Again, researchers can emphasize the approaches in preserving natural systems while also achieving the human goal for further research. Through these proper researches, people will be aware of the significance of environmental behaviour.

Conclusions

Individual efforts to lessen the negative impact of environmental degradation by enhancing and maintaining the environment are referred to as pro-environmental conduct. Values, such as caring for nature and safeguarding the environment, have been shown to have an important role in explaining pro-environmental behaviour (Begum et al. 2021). The environment is one of humanity's most vital components. Human behaviour in relation to the environment will be influenced by ongoing interactions between humans and the environment. It urges people to adjust their habits to lessen the negative consequences of environmental devastation (Gifford and Nilsson 2014). For this reason, people should be aware of environmental behaviour. If one has proper knowledge on the topic, they can understand the significance more deeply. Furthermore, this study can gain more significance since it tackles a pressing worldwide issue, suggests educational solutions, employs cutting-edge research techniques, and offers insights into the state of the field. Its conclusions can contribute to the development of practices and regulations that encourage sustainable lifestyles and lessen the damaging effects of consumerism on the environment.

The methods section outlines selecting publications for bibliometric review, trend analysis, and text mining. It also depicts the methodology employed in this study to examine pro-environmental behaviour. The most often used terms are displayed in the tree-map and subject trend, demonstrating the importance of long-term development. Following that, bibliometric analysis helps us comprehend document bibliographic coupling analysis and the author keyword co-occurrence network. In

this example, the findings involved related authors, papers, and keyword co-occurrence. The important discoveries are the document trend analysis from the biblioshiny in R- tool and the latent Dirichlet allocation from the text mining technique. The trend analysis illustrates the number of citations a journal receives each year.

However, this study has some limitations, such as the tools we used only supported the Scopus database which lacks a detailed view on this topic. Therefore, the audience are encouraged to do research using other databases which might clear others' confusions and views. Sustainability and sustainable development have become two of the most used concepts, so by concentrating on tactics that support sustainability and making sure that people are aware of the long-term advantages and effects of their environmentally friendly actions, researchers can help to promote pro-environmental behaviour change. This strategy may be crucial for bringing about long-lasting, constructive behavioural changes that promote sustainability and environmental preservation.

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