

## **Eco-literacy in Science Learning: A Review and Bibliometric Analysis**

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### **Abstract**

Eco-literacy plays an important role in learning awareness about protecting the environment. Ecoliteracy needs to be given to children early to instill basic environmental preservation behaviors. There has been a decline in environmental quality due to low awareness of eco-literacy. This study aims to review bibliometric literature on applying eco-literacy-based learning to increase student awareness of the importance of protecting the surrounding environment. The literature review was taken from articles obtained using the Publish or Perish (PoP) application from 2017 to 2022 and obtained 67 articles. The articles are then analyzed using VOSviewer software to map and look for research gaps that are still possible to be researched. Some topics provide research opportunities, including "education", "environmental education", "environmental", "sustainability", and "ecological literacy". From the point of recent research on the application of student eco-literacy-based learning models for environment-related materials still provides room to be carried out.

Keywords: Eco-literacy, Science Learning, Bibliometric

### **INTRODUCTION**

Ecoliteracy is the ability to understand the basic principles of ecology, namely the process by which the earth's ecosystems sustain living systems and balance on earth (Stone, 2017). A strong understanding of eco-literacy indicates that a person has a high understanding and level of awareness of the importance of maintaining the relationship between living things and the surrounding environment. The core subject of eco-literacy is sustainability, which emphasizes that everyone working and studying sustainable development should design indicators and measurements to evaluate eco-literacy (Okur-Berberoglu, 2018). According to Okur-Berberoglu (2018), Ecoliteracy has five sub-districts: ecological intelligence, social intelligence, emotional intelligence, economic intelligence, and green consumer behavior. Social, emotional, and economic intelligence has a relationship with ecological intelligence, while ecological intelligence has a relationship with green consumer behavior. Suppose economic subjects' social, emotional, or economic intelligence is improved. In that case, it will affect ecological intelligence and thus will give birth to green consumer behavior according to alternative eco-literacy models.

Ecological knowledge is the basis of individual attitudes and actions toward the environment. The higher the knowledge a group of individuals possesses, the higher the attitude toward the environment (Noviana et al., 2019). Eco-literacy is understanding and internalizing the relationship of sustainable ecology in nature and transferring this sustainable lifestyle to everyday life, even though eco-literacy does not have only one definition and uniqueness (Okur-

Berberoglu, 2018). Ecological intelligence is always related to human awareness of the environment. For this reason, it is very important to build awareness from an early age to preserve nature and its sustainability (Noviana et al., 2018)

Eco-literacy is the most important requirement for a sustainably functioning society in the 21st century (Locke et al., 2013). Intelligence and information processing from limited resources, waste, energy, and biodiversity are essential for human populations' health, happiness, and survival (Pitman et al., 2018). One solution to overcome global environmental crises and disasters are to build a sustainable human society based on what is referred to as ecological literacy, which is the ability of a person to understand the organizing principles that apply to all living systems and use them as guidelines in creating a sustainable society (Capra, 2003). Eco-literacy, or ecological intelligence, is a person's skill to adapt to the environment of the domain or place of residence (Lees, 2017).

Jordan et al., (2009) identified six components of eco-literacy: (1) the ecological Self, a sense of interconnectedness with the life cycle based on compassion, empathy, and a broad view of the world; (2) active notions of place and citizenship, engagement with local culture, history, and organic communities alongside ecosystems; (3) systems thinking and relationships, a sense of relationality, connectedness, and context; (4) Ecological paradigms, the study of wholes, relationships, and networks, with an emphasis on contextual knowledge, quality considerations, attention to processes, and the study of patterns; (5) educational pedagogy for sustainability, an experiential, participatory, and multidisciplinary approach, with a focus on the learning process; and (6) reading about the natural and cultural world, engaging with nature as early as possible with eco-literacy as the first literacy. Nevertheless, per (Cutter-Mackenzie & Smith, 2003). The four stages of ecoliteracy are as follows: (1) illiteracy, lack of knowledge, and widespread misconceptions concerning environmental issues; (2) Nominal ecoliteracy, which involves the introduction and use of some fundamental phrases used in speaking about the environment and the start of problem-solving by identifying environmental challenges; (3) functional/operational ecoliteracy, which is the understanding of the structure, operation, and interaction of environmental systems with human systems; (4) highly developed eco-literacy, a complete understanding of how communities and individuals interact with one another and environmental systems, as well as how to do so sustainably, comprehensive knowledge of environmental challenges, familiarity with sustainability frameworks, capacity to synthesize environmental data and take actions that promote environmental sustainability.

Ecological literacy alters people's perspectives and makes them aware of the significance of maintaining a global ecological consciousness (Febriani et al., 2020). Ecological

literacy is the knowledge that society has acquired on the significance of the environment. Students that are literate in environmental issues have the knowledge and skills to approach environmental problems holistically. When someone reaches the ecoliteracy level, they comprehend the value of preserving the environment as a place to live and interact with other living things (Keraf, 2014).. In order to be ecologically literate, one must comprehend the guiding principles of the systems that support life. It takes into account a person's environmental knowledge, attitudes, and behaviors. This type of individual is interested in resolving the issues that people have created on the world and has some knowledge of ecological issues (Schimek, 2016).

According to Nadiroh et al. (2019), eco-literacy is the understanding and behavior a person has toward the environment. The findings of Nadiroh's study from 2019 indicate that thinking skills and ecoliteracy do not interact in any way. Additionally, there is no relationship between gender and ecoliteracy. Previous study is pertinent and offers fresh empirical evidence that ecoliteracy and critical thinking abilities are the factors that lead someone to support environmental preservation. The interplay between ecoliteracy and critical thinking abilities had a minimal impact, nevertheless. Additionally, because both gender viewpoints and relationships in ecoliteracy contribute equally, they must be disregarded. As a result, early ecoliteracy application is necessary (Nadiroh et al., 2019).

According to McBride et al. (2013), an individual's attempt to survive under the aegis of sustainable development can be considered evidence of their eco-literacy. They can assess which actions will positively impact sustainable development and what role intuition, creativity, and spirituality may play in doing so. Eco-literacy can help environmental education achieve its goals, but unless governments, education ministries, providers of teacher education, primary schools, and teachers themselves make a system-wide commitment to environmental education and the creation and dissemination of knowledge, such initiatives are unlikely to significantly change the state of environmental education today (Cutter-Mackenzie & Smith, 2003).

The demand for eco-friendly items has increased as a result of research on environmental eco-literacy (Suwondo & Pramudana, 2016). This has sparked the development of new environmental ethics and raised people's awareness of the need to drastically alter their consumption patterns. This is due to the following reasons: (1) eco-literacy positively and significantly affects consumer attitudes; (2) eco-literacy positively and significantly affects the willingness to purchase environmentally friendly products; (3) attitudes positively and insignificantly affect the willingness to purchase environmentally friendly products; and (4) attitudes are considered to significantly mediate the relationship between eco-literacy and the

willingness to purchase environmentally friendly products. Research results (Valentine, 2016), Carried out based on the neglect of environmental conditions from the academic world's attention, including schools. Schools cannot transmit environmentally charged knowledge, so students do not yet have ecological intelligence or eco-literacy. To facilitate the delivery of students' eco-literacy, it is carried out by utilizing rubber plantations which are the main commodity of the community as a learning resource that is integrated into Social Sciences learning.

The SDGs are a set of 17 objectives with 169 targets and 247 indicators that were announced by the UN and contained in the publication *Transforming our world: the 2030 Agenda for Sustainable Development* (United Nations, 2015). The 17 goals aim to address issues that are vital to human survival on a global scale, establish environmental boundaries and critical levels for the use of natural resources, and acknowledge that efforts to reduce poverty must coexist with those to advance economic development (UNESCO, 2017). Along with aims for education, health, social protection, and career possibilities, environmental protection and combating climate change are also included. Climate change is a major worry right now, and environmental harm is escalating. Therefore, students' understanding of eco-literacy and its application in everyday life needs to be done from an early age. A lot of research has been done related to eco-literacy. Therefore, it is necessary to study existing research results to find things that can be done further.

## **METHOD**

Information science bibliometric studies can show trends in document usage and the growth of literature or information sources in a discipline (Tupan, 2016). According to Elgaard and Wallin (2015), bibliometric analysis is rapidly becoming recognized as a resourceful tool for the professional community as well as an academic one for bibliometrists. The scientific community and the general public will benefit from bibliometric mapping, which will assist turn the publication's numerous metadata into maps or visualizations that are easier to digest in order to acquire insightful information (Tanudjaja & Kow, 2018). The five-stage bibliometric

analysis methodology used in this work is depicted in Figure 1 (Tranfield et al., 2003).

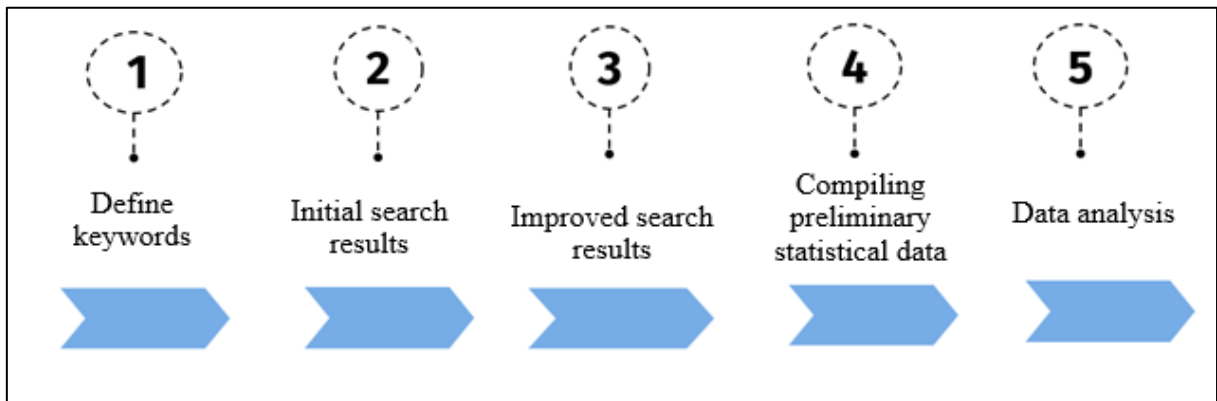


Figure 1. Bibliometric analysis steps

The detailed description of the five stages are:

1. Define keywords

The keyword used is "eco-literacy" with the Google Scholar (GS) database source, which is the largest database using the Publish or Perish (PoP) application, which is a very effective application for searching articles or journals in GS (Baneyx, 2008). Another important practical reason for using GS is that it is available free of charge to anyone with an internet connection and is generally praised for its speed (Bosman et al., 2006). Search for articles with the keyword "ecoliteracy" in the PoP application with the name of the journal article between 2017 and 2022 and limit up to 100 scientific articles.

2. Initial search results

The initial search results obtained 100 articles, then stored in the Research Information System (RIS) format to obtain important information related to article titles, author names, abstracts, affiliate names, keywords, and reference sources.

3. Improved search results

In this step, the author filters information that only articles in the form of journals will then be analyzed, while proceedings, newspapers, book reviews and book chapters will not be processed. The selected journals will be saved as RIS (Research Information Systems) files and imported into VOSviewer software for further analysis.

4. Compiling preliminary statistical data

Selected journals are stored in the form of RIS with complete components in the form of publication year, volume, page number, and others, then analyzed, and grouped by publication year, publication source and publisher. The results of this grouping can be used to choose which articles have a direct or close relationship with the article's title, which will later be used for further research.

## 5. Data analysis

The software used to analyze bibliometrics in this study was PoP (Baneyx, 2008), and further, to analyze and visualize bibliometric networks, used VOSviewer software. VOSviewer software is used because of its capacity to work effectively with big data and establish and provide a variety of visually appealing analyses, investigations, and graphs (van Eck & Waltman, 2010). VOSviewer can generate keyword maps based on shared networks or create maps of publications, authors, or journals based on co-citation networks. Bibliometric applications can be divided into two parts, namely: 1) bibliometric calculations (performance) of indicators at different behavioral levels; and 2) visualization analysis of bibliometric networks (Mallig, 2010).

## RESULTS AND DISCUSSION

With Publish or Perish software, 100 articles were obtained from Google Scholar data sources with the keyword "eco-literacy", published from 2017-2022. After the screening, 67 articles relevant to the topic to be discussed were obtained. Figure 2 shows the results of refining the literature search and sorting by ranking.

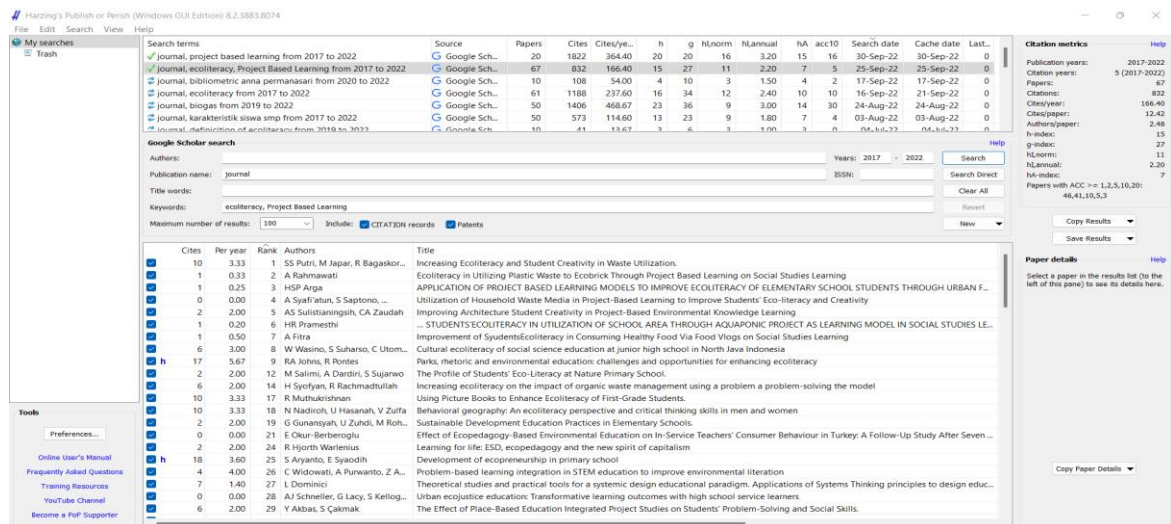


Figure 2. Article search results using Publish or Perish software with Google Scholar data sources

The results of the PoP analysis obtained search metric data in GS in the form of a comparison of initial searches and refinement results which are the results of analysis based on PoP software from determining the keyword "eco-literacy". At the initial stage, 100 articles were obtained from the GS database with 948 citations (189.60 citations/year). After improvement, 67 articles were obtained with 832 citations (166.40 citations/year). The complete metric data before and after article improvement can be seen in Table 1.

Table 1 Initial search data on GS

Metric data	Initial search	Refinement search
Sourch	2017-2022	2017-2022
Article	100	67
Cite	948	832
Cites/year	189,60	166,40
Cites/article	9,48	12,42
Author/article	2,44	2.48
H Index	15	15
G index	28	27
Hi norm	11	11
Hi annual	2.20	2.20

Furthermore, to get more contributive data, in this study, researchers took 10 articles with the keyword "eco-literacy", which had the top 10 rankings can be seen in Table 2.

Table 2. Top ten ranking of keyword-related articles “Eco-literacy”

No	Publication year	Authors	Title
1	2019	S.S Putri, M. Japar, R. Bagaskorowati	Increasing eco-literacy and student creativity in waste utilization
2	2019	A.Rahmawati	Eco-literacy in utilizing plastic waste to eco-brick through project-based learning on social studies learning
3	2018	H.S.P. Arga	Application of project-based learning models to improve eco-literacy of elementary school students through urban farming
4	2022	A. Syafi'atun, S.Saptono, N.M.D. Putra	Utilization of household waste media in project-based learning to improve students' eco-literacy and creativity
5	2021	AS. Sulistianingsih, ZCA. Dalu	Improving architecture student creativity in project-based environmental knowledge learning
6	2017	Pramesthi	Students' eco-literacy in utilizing of school area through aquaponic project as learning model in social studies learning
7	2020	A Fitra	Improvement of student eco-literacy in consuming healthy food via food vlogs on social studies learning
8	2020	W Wasino, S. Suharso, C Utomo	Cultural eco-literacy of social science education at junior high school in north java Indonesia
9	2019	RA Johns, R Pontes	Park, rhetoric, and environmental education: challenges and opportunities for enhancing eco-literacy
10	2021	M Salim, A Dardiri, S Sujarwo	The profile of students' eco-literacy at nature primary school

Table 2 shows the top 10 rankings of publication years and journal titles with the keyword "eco-literacy" and Table 3 shows the top seven most cited articles. By using VOSviewer software, data from the results of analysis related to the keyword "eco-literacy" are visualized in the form of three different bibliometric mapping visualizations, namely, network visualizations that show the relationship of "eco-literacy", overlay visualizations that show how big per year articles are related to "eco-literacy" and density visualizations that show the number

of articles discussing "eco-literacy" which are characterized by concentration and The brightness of the colors in the displayed Image.

Table 3. Seven Top citation value articles with the keyword "ecoliteracy"

No	Publication year	Cites	Author	Title
1	2018	167	J Kaur, R Sidhu, A Awasthi, S Chauhan	A DEMATEL based approach for investigating barriers in green supply chain management in Canadian manufacturing firm
2	2018	145	A Al Mamun, MR Mohamad, MRB Yacob	Intention and behavior towards green consumption among low-income households.
3	2018	55	J Hermes, I Rimanoczy	Deep learning for a sustainability mindset
4	2020	43	N Nurwidodo, M Amin, I Ibrohim, S Sueb	The role of eco-school program (Adiwiyata) towards environmental literacy of high school students.
5	2017	39	H Meilinda, BA Prayitno, P Karyanto	Student's environmental literacy profile of Adiwiyata green school in Surakarta, Indonesia
6	2019	25	G Malandrakis, P Papadopoulou	An education for sustainable development Self-efficacy scale for primary pre-service teachers: construction and validation
7	2017	24	F Ferreira	Critical sustainability studies: a holistic and visionary conception of socio-ecological conscientization

Bibliometric analysis of data generated from GS with the keyword "eco-literacy" in RIS format using VOSviewer software resulted in a network visualization of eco-literacy-related data, as shown in Figure 2.

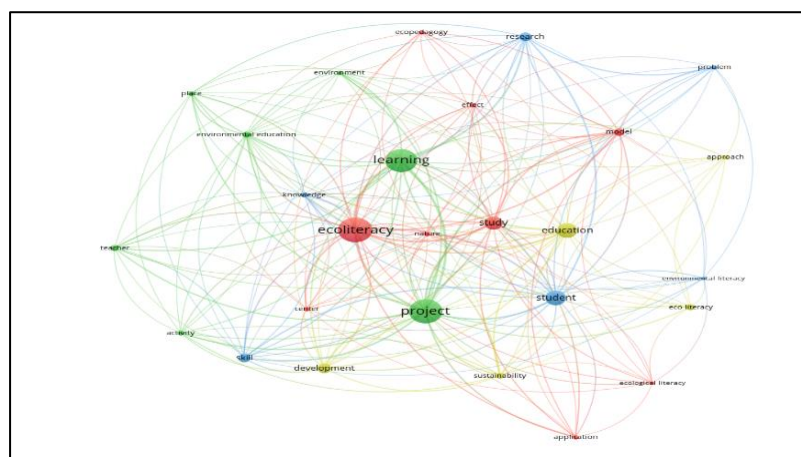


Figure 2. Network visualization on GS data base

From the visualization of Figure 2, in total, there are 27 topics or words related to "eco-literacy" in four research clusters marked in red for cluster 1 is the "eco-literacy" cluster itself consisting of 21 networks, green for cluster 2, namely the "project" and "learning" clusters with 26 networks, blue as cluster 3 for the "student" cluster with 22 networks and yellow for cluster



4 for "education" with 24 networks, The total number of links is 223 with a total link strength of 482.

The results of the bibliometric analysis with VOSviewer produce a network visualization that displays four clusters, as shown in Table 4.

Table 4. Four Cluster Articles

No	Cluster	Topic
1	Cluster 1: red	Eco-literacy (24), study (24), Center (13), model (19), nature (17), effect (16), eco-pedagogy (11), application (10), ecological literacy (12).
2	Cluster 2: green	Project (26), Learning (21), environmental education (19), place (14), environment (15), activity (15), teacher (14).
3	Cluster 3: blue	Student (22), skill (16), research (17), problem (12), environmental literacy (13).
4	Cluster 4: yellow	Education (24), approach (10), eco literacy (11), sustainable (16), development (17).

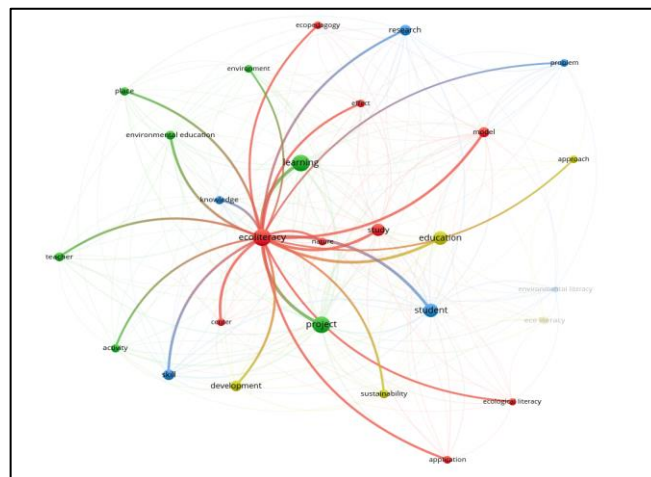


Figure 3. Research related to eco-literacy

Figure 3 shows the association of the most research on "eco-literacy" as the main cluster that has a large circle which indicates that many researchers have carried out research for eco-literacy, but research on literacy ecology and its application is still rarely found, this is characterized by a long distance from "eco-literacy" and a small circle size. The "eco-literacy" cluster is part of the items considered important for analysis. This suggests we can interpret "eco-literacy" as a publication's most widely used keyword.

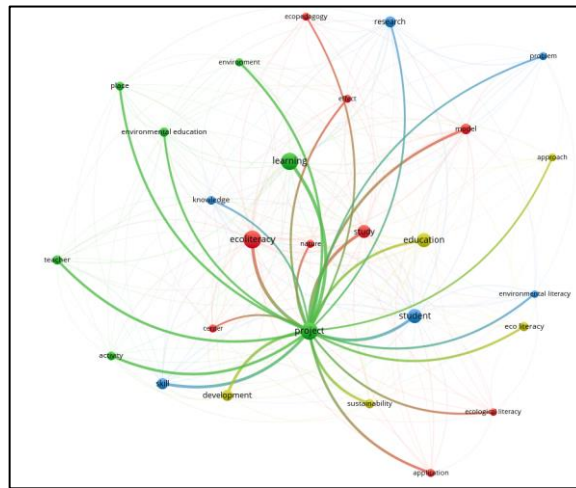


Figure 4. Cluster both "project" and "learning"

Figure 4 shows the second cluster, the "project" cluster, which is also related to the topic "learning", showing that the topics that are least studied are related to the topics of "place", "environmental education", and also "environment" seen from a distance away from the centre of the second cluster. This cluster contains several topics that provide a gap for receptivity to be researched but have a strong relationship to the keyword "eco-literacy".

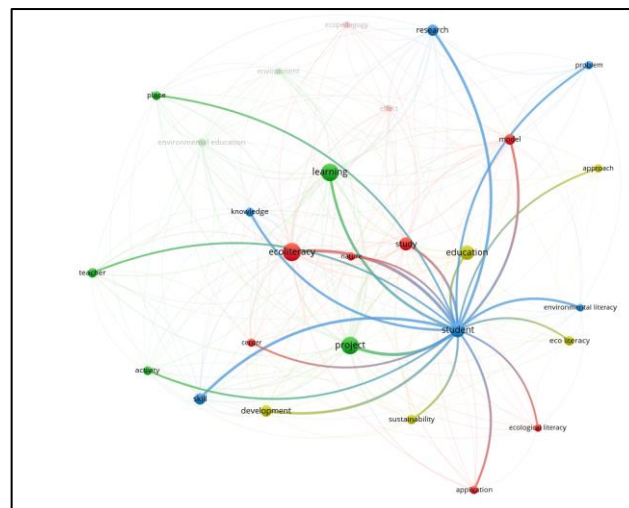


Figure 5. The third cluster "student"

Figure 5 shows the "student" cluster consisting of "research," "problem," and "skill" topics located very far from the topic of the cluster itself, which means that there is still a gap for research and development on the topic of the topic. The topics "research," "problem," and "skill" can be examined about "eco-literacy" and "student." Of course, this is inseparable from learning activities in class.

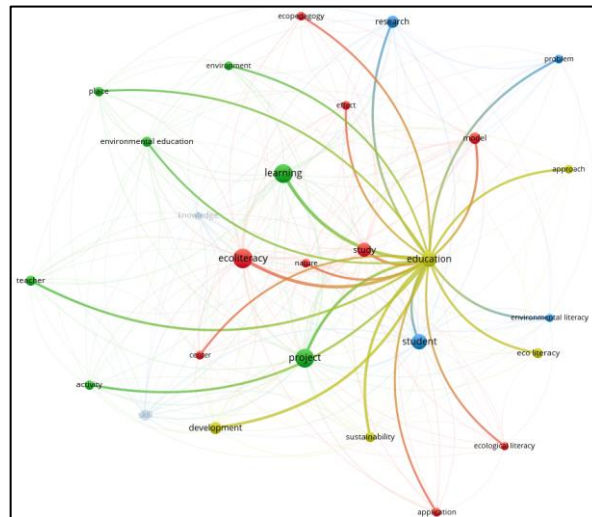


Figure 6. The fourth cluster "education"

Figure 6 shows the fourth cluster in yellow with 24 related topics, including "development," "sustainable," "eco-literacy," and "approach," which are still opportunities to be researched. This cluster involves a relationship between "eco-literacy" and sustainability, which can be further investigated as an independent variable.

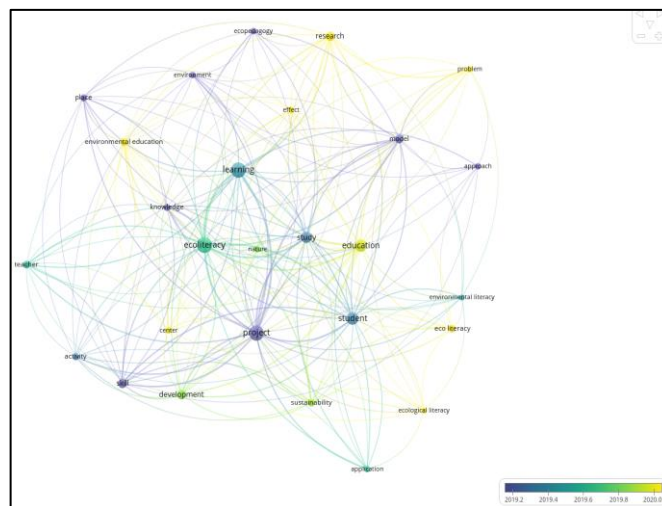


Figure 7. Overlay Visualization

Figure 7 shows the "overlay visualization" of GS metadata related to "eco-literacy" The yellow topics indicate topics that are new and rarely researched, namely, topics related to "education," "environmental education," "environmental," "sustainability,," and "ecological literacy" still have gaps as research material. This is in line with Figure 8, which displays density visualization, an image showing that the topic is dark, which means there are still few people researching the study.

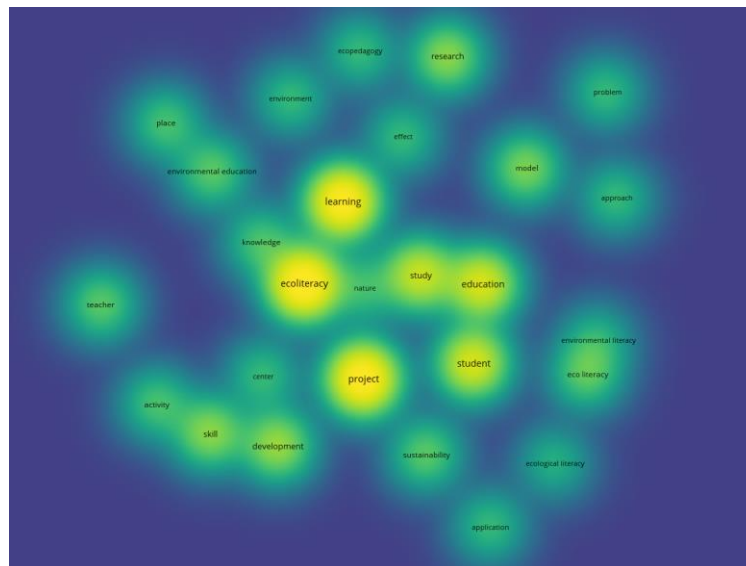


Figure 8. Density Visualization connected “eco-literacy”

Figures 8, labels represent items the same way as in the label view. Each point on the map has a color that depends on the density of the items at that point. The color of a point on the map depends on the number of items around that point and the importance of adjacent items. The density view is very useful for getting an overview of the general structure of the map and for drawing attention to the most important areas of the map. Figure 8 provides labels marked with each topic having different color densities. It identifies that the color of each topic point depends on the number of topics related to the other topics. This gives an idea of the general structure on the map: bright yellow topics indicate that this topic has many people doing research, while dark green topics indicate that there are still a few people doing research.

The mapping results using VOSviewers related to eco-literacy research show several topics that provide research opportunities. The topics are "education," "environmental education," "environmental," "sustainability," and "ecological literacy." The topic has the potential to be further researched because it impacts accelerating sustainable development goals and is closely related to education for sustainable development. In Indonesia, research related to eco-literacy is still dominated by general programs related to the school environment. There is still little research on eco-literacy related to applying learning models in the classroom.

## CONCLUSION

The results of filtering information with PoP software sourced from Google Scholar data for the last five years, from 2017 to 2022, obtained 67 journals and 832 citations (166.40 citations/year) related to the keyword "eco-literacy". The resulting data was then analyzed with VOSviewer software, obtaining four clusters that produced 27 topics with 223 networks and a total strength of 482 networks.

The results of bibliometric analysis related to "eco-literacy" show several topics that provide research opportunities. The topics are "education," "environmental education," "environmental," "sustainability," and "ecological literacy." Thus, from the point of novelty, research on applying student eco-literacy-based learning models for environment-related materials still provides room to be done.

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