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Trend dan Fokus Riset Plants Awareness dalam Pembelajaran Biologi: Analisis Bibliometrik

Trends and Research Focus of Plant Awareness in Biology Learning: A Bibliometric Analysis

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Abstrak

Tumbuhan merupakan komponen fundamental dalam kehidupan dan ekosistem, namun kesadaran manusia terhadap peran pentingnya masih rendah dibandingkan dengan hewan sebuah fenomena yang dikenal sebagai *plant awareness disparity*. Oleh karena itu, pemetaan arah dan fokus riset tentang *plant awareness* dalam pembelajaran menjadi penting untuk memperkuat basis ilmiah dan pedagogis dalam menghadapi tantangan keberlanjutan. Artikel ini bertujuan untuk menganalisis tren, aktor utama, fokus tematik, dan arah perkembangan riset *plant awareness* dalam konteks pembelajaran berdasarkan publikasi ilmiah terindeks Scopus periode 2020–2025, menggunakan pendekatan *bibliometrik*. Sebanyak 62 artikel dianalisis dengan bantuan perangkat lunak VOSviewer untuk mengeksplorasi pola kata kunci, jaringan kolaborasi, serta identifikasi institusi dan penulis paling produktif. Hasil analisis menunjukkan peningkatan signifikan dalam jumlah publikasi, khususnya pada tahun 2022 hingga 2024, dengan lonjakan tertinggi pada tahun 2023 (n=21 artikel). Kontributor utama dalam bidang ini adalah K.M. Parsley dan B.C. Stagg, yang masing-masing menyumbang dua publikasi. Fokus riset terbagi ke dalam beberapa klaster tematik, seperti persepsi siswa terhadap tumbuhan, pendidikan berkelanjutan, visualisasi botani, dan integrasi kurikulum sains. Temuan ini menegaskan pentingnya integrasi kesadaran terhadap tumbuh.

Kata kunci: Bibliometrik; *Kesadaran tumbuhan*; Pembelajaran biologi

Abstract

Plants are fundamental components of life and ecosystems, yet human awareness of their importance is low compared to that of animals-a phenomenon known as the plant awareness disparity. Therefore, mapping the direction and focus of research on plant awareness in learning is important to strengthen the scientific and pedagogical basis in facing sustainability challenges. This article aims to analyze the trends, main actors, thematic focus, and direction of plant awareness research development in the context of learning based on Google Scholar-indexed scientific publications for the period 2020-2025, using a bibliometric approach. A total of 62 articles were analyzed with the help of VOSviewer software to explore keyword patterns, collaboration networks, and the identification of the most productive institutions and authors. The analysis showed a significant increase in the number of publications, especially from 2022 to 2024, with the highest spike in 2023 (n=21 articles). The main contributors in this area were K.M. Parsley and B.C. Stagg, who each contributed two publications. The research focus is divided into several thematic clusters, such as student perceptions of plants, sustainable education, botanical visualization, and science curriculum integration. The findings confirm the importance of integrating awareness of growing.

Keywords: *Bibliometrics; Plants awareness; Biology learning*

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INTRODUCTION

Plant awareness is one of the important topics that has begun to receive attention in the realm of education, especially in biology and environmental learning. This term developed in response to the phenomenon of plant blindness, which is the inability or unconsciousness of humans to pay attention to and appreciate plants in everyday life (Parsley, 2020). This

phenomenon has an impact on the low appreciation of the role of plants in the ecosystem, and contributes to the ecological crisis and the lack of concern for biodiversity conservation. In many educational settings, students tend to focus more on animals due to their movements, expressions, and perceived emotional connections, making plants appear static and less engaging (Stapleton & Lynch, 2021). This misperception reduces the integration of plants as central themes in ecological discussions and weakens students' understanding of food webs and habitat balance (Bayati, 2023). As a result, plant awareness is now being promoted as a crucial foundation for fostering environmental literacy and sustainability values.

In the context of education, low awareness of plants is reflected in teaching materials, textbook illustrations, and teaching approaches that tend to emphasize animals or human aspects rather than plants (Brownlee et al., 2023). This has led to the emergence of various studies that seek to understand and develop plant awareness, especially through educational and cultural approaches (Marcos-Walias et al., 2023; Stagg & Dillon, 2022). The imbalance in representation has implications for how students perceive the ecological importance of flora compared to fauna (da Silva et al., 2023). A study was conducted by Marcos-Walias et al. (2023) on 259 students from elementary school to university in the Spanish education system to evaluate their species literacy, particularly regarding local flora and fauna, the possibility of its improvement across all levels of education, and to assess whether PAD is a reality among students. Another study also found that 345 Austrian high school students participated in a questionnaire study that showed a "lack of awareness" of plants among students (Pany et al., 2024). Therefore, it is necessary to explore ways to recontextualize the presence of plants in students' lives (Dean, 2024).

Efforts to build plant awareness in education are growing along with the emergence of research that integrates this concept into environment-based learning, ethnobotany, and even educational games (Chisalita et al., 2022; de Almeida et al., 2024). The focus of research also extends to the development of measurement instruments such as the Plant Awareness Disparity Index (Parsley, 2020), to evaluating the influence of students' perceptions and motivation towards the existence of plants (Fiel'ardh et al., 2023; Pany et al., 2024). These innovations aim to make plant learning more interactive and relatable for students across age groups (Leo-Ramírez et al., 2023). For instance, digital applications and storytelling-based modules are employed to simulate real-life plant interactions and their ecosystem functions. Such strategies are not only useful in cognitive development but also foster emotional and affective connections with nature.

However, until now, there have not been many studies that systematically map how trends and research focuses related to plant awareness have developed in the academic literature, especially those published in the last five years. In fact, this mapping is important to provide new directions for curriculum development, learning strategies, and more integrated ecology-based education policies. A systematic overview would allow educators to understand the evolution of

research themes, including the shift from theoretical frameworks to practical applications (Luft et al., 2022). It would also highlight gaps in regional and demographic representation in plant awareness studies. Moreover, such mapping is valuable for evaluating whether existing interventions have effectively reduced the disparity in attention between plants and animals in educational contexts.

Bibliometric analysis is a particularly suitable method for synthesizing developments in plant awareness research, especially within the educational context. Unlike traditional literature reviews, bibliometrics enables a systematic and quantitative assessment of publication patterns, thematic emphases, and authorial networks, which is essential for identifying how the concept of plant awareness has evolved, been interpreted, and applied across various educational settings. This method is especially powerful in revealing underexplored areas, such as plant awareness in primary or teacher education, where narrative reviews may lack coverage due to the fragmented nature of research.

By analyzing scientific publications from reputable databases such as Scopus, bibliometric analysis provides both a macroscopic and microscopic view of how knowledge in this field is produced and disseminated (Fang et al., 2021; Stagg et al., 2025). It allows researchers to trace the historical trajectory of keywords, identify the most influential publications and citation patterns, and detect thematic clusters that signal emerging research frontiers. Moreover, this approach can illuminate interdisciplinary linkages such as the intersection of botany, environmental pedagogy, and digital learning innovations that contribute to the framing of plant awareness in education.

This study aims to analyze the trends and focus of research on *plant awareness* in educational contexts by using Scopus-indexed scientific publication data from 2020 to 2025. The results are expected to provide a comprehensive mapping of how the concept has developed within educational literature, serving as a foundation for educators, curriculum developers, and policymakers to integrate plant-focused content into teaching practices. By synthesizing recent studies, the research also seeks to identify effective pedagogical models and innovations that promote meaningful student engagement with plant life. The findings will contribute empirical evidence for designing curricula that position plant awareness on par with animal-related content, countering long-standing biases. Ultimately, this study positions *plant awareness* as a critical and measurable component of broader ecological literacy, thereby offering a targeted yet integrative contribution to environmental education and biodiversity conservation efforts.

METHOD

This study uses a bibliometric analysis approach to identify trends and research focuses related to plant awareness in the context of learning. Bibliometric analysis is a method that uses bibliographic data from scientific publications to trace the development of research, collaboration

networks, and mapping of topics and key terms that develop over time (Orduña-Malea & Costas, 2021). By analyzing the frequency and patterns of key terms, this study aims to provide a comprehensive understanding of how plant awareness has evolved within educational settings. Additionally, the results of this analysis will help identify gaps and emerging areas in plant-related learning research that require further exploration.

The data in this study were obtained from the Google Scholar database for the period 2020 to 2025. The search strategy was conducted using main keywords such as "plant awareness" OR "plant literacy" OR "plant knowledge" OR "botanical education") AND ("biology education" OR "biological education" OR "life sciences education" OR "science education") AND ("curriculum" OR "teaching" OR "pedagogy" OR "instruction") AND ("student engagement" OR "learning outcomes" OR "educational practices" OR "assessment". The initial search results yielded more than 80 articles. However, to maintain the relevance and focus of the research, a screening process was conducted with inclusion criteria: (1) English articles, (2) directly related to education or plant awareness, and (3) complete metadata (title, author, journal, year, and type of publication). After the selection process, 62 relevant articles were obtained for analysis.

The classified data were then processed using three tools, namely: 1) Microsoft Excel for descriptive statistics processing (publication frequency per year, distribution by journal, author affiliation, and country); 2) VOSviewer to visualize author collaboration network maps, co-authorship between institutions, and co-occurrence of keywords that appear most frequently in related publications; and 3) Publish or Perish is used complementarily to evaluate the citation metrics and influence of key articles in the scholarly network.

The categories of document types analyzed included journal articles (the majority), review papers, conference papers, and several book chapters directly related to plant awareness education. Each publication was then classified based on the variables of year of publication, journal source, author's institutional affiliation, country of origin, and the main keywords used.

Of the 81 articles we found, only 62 were processed further, based on their year of publication (Figure 1). We did not extract any further, as the purpose of this research was to map the development of research on "Plant Awareness". With this approach, this research is expected to provide a comprehensive picture of the dynamics and trends of plant awareness research, especially in the context of learning and environmental education. The results of this analysis provide a basis for evaluating the direction of scientific development and the potential for cross-country and multidisciplinary research collaborations in the future.

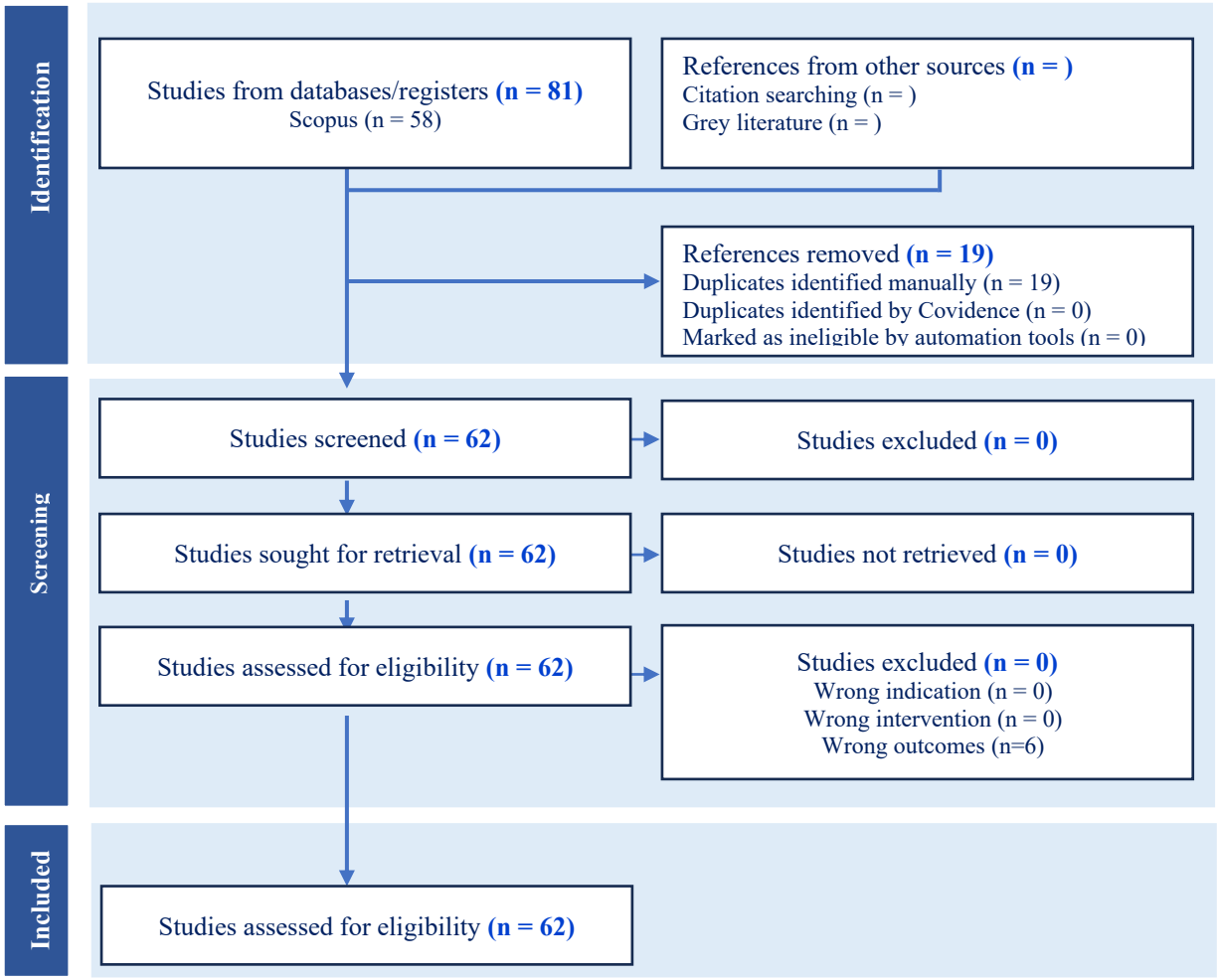

Figure 1. Prism Diagram

RESULT AND DISCUSSION

Result

1. Annual publication trends

Mapping annual publication trends is the first step to assessing the dynamics of research development related to plant awareness in learning. Since 2020, attention to this issue has continued to experience a significant increase, especially in the period 2022 to 2025. This surge shows that the issue of plant awareness is gaining a place in the discourse of science and environmental education. The increase in the number of publications also reflects the growing concern for the integration of ecological values in the curriculum and the importance of responding scientifically to the phenomenon of plant awareness disparity.

Table 1 shows that 2024 was the peak of publication productivity with a total of 17 articles, followed by 2023 and 2022, which contributed 14 and 12 articles, respectively. Meanwhile, at the beginning of the period (2020 and 2021), the number of publications was relatively low. This distribution indicates that the study of plant awareness in education is a newly developing field but has a promising upward trend in the future.

Table 1. Number of Publications per Year (2020-2025)

Year of Publication	Number of Articles
2020	9
2021	5
2022	12
2023	14
2024	17
2025	5
Total	**62**

Source: Data processed from Scopus (2020-2025)

Based on the publication data analyzed from 62 articles related to plant awareness relevant to the field of education and learning, it can be seen that the research trend has increased significantly since 2020. 2020 was an important starting point with 9 publications, among which was marked by a monumental article from Parsley (2020), who proposed changing the term from plant blindness to plant awareness disparity, as a form of criticism of the term, which was considered to have a negative meaning and a lack of solutions.

A decrease in the number of publications occurred in 2021, with only 5 articles successfully published. This decline was likely influenced by the impact of the COVID-19 pandemic, which reduced research productivity in various countries (Sakoda et al., 2021). However, the trend increased sharply again in 2022 and reached its peak in 2024 with a total of 17 articles. This trend indicates increasing academic attention to plant awareness issues in education, especially through transdisciplinary approaches such as sustainable education (Fiel'ardh et al., 2023) and ethnobotany (Cordeiro et al., 2020).

The year 2023 also showed high productivity with 14 publications. This shows the consistency of research focus on the integration of plant awareness in the context of student learning and future teachers. For example, a study by Marcos-Walias (2023) analyzed plant awareness disparities by education level in Spain, while Brownlee (2023) examined visual bias in biology textbooks.

As of April 2025, it has recorded 5 relevant articles. Interestingly, one of this year's publications (Stagg et al., 2025) proposes an educational model framework for systematically building plant awareness, suggesting that the focus of research is moving towards theory development and long-term educational interventions.

Overall, the year-on-year publication trend shows that plant awareness is no longer a fringe theme in ecology and education but has evolved into a multidisciplinary field of study receiving global attention. The surge in publications, especially in 2022-2024, can be interpreted as a response to global ecological issues, the need for sustainable education, and the emerging awareness of anthropocentrism bias in science education (Amprazis & Papadopoulou, 2024; Fang et al., 2021).

2. The source of most journals

Identifying the journals that are the main publication venues in plant awareness research provides insight into the direction of scientific dissemination and the academic forums that are the center of discussion in this field. By analyzing publication sources, researchers can determine the most relevant target journals for future dissemination of study results. In addition, journal trends also reflect the disciplinary dimension of science that oversees the issue of plant awareness, whether from the perspective of biology, education, environment, or technology.

Table 2 shows that the Plants People Planet journal is the most dominant publication channel with a total of 8 articles, followed by the Journal of Biological Education with 4 articles. Several other journals, such as Sustainability (Switzerland), Plants, Heliyon, and International Journal of Science Education, each contained two articles. The other 38 articles were spread across a more diverse range of journals. This pattern shows that the issue of plant awareness is interdisciplinary, with major contributions from journals focusing on biology education, environmental science, and sustainability.

Table 2. Source of most publications (2020-2025)

Journal Name	Number of Articles
Plants People Planet	8
Journal of Biological Education	4
Sustainability (Switzerland)	2
Plants	2
Nuclear Engineering and Technology	2
International Journal of Science Education	2
Advances in Intelligent Systems and Computing	2
Heliyon	2
Others	38

Source: Data processed from Scopus publications (2020-2025)

Of the total 62 articles analyzed, it can be seen that the Plants People Planet journal is the main source of publications in the study of plant awareness with 8 articles. This journal focuses on the relationship between humans and plants in the context of the environment, ethics, and education, making it a very suitable place for research that discusses plant blindness, public perception, and ecological awareness (Parsley, 2020; Stagg et al., 2025).

The next position is occupied by the Journal of Biological Education with 4 articles, which shows that the issue of plant awareness has been integrated into the main discourse of biology education. Publications in this journal generally highlight the design of plant awareness measurement instruments, as well as the influence of learning on students' perceptions and attitudes towards plants (Brownlee et al., 2023; Pany et al., 2024).

Furthermore, the journals Sustainability (Switzerland), Nuclear Engineering and Technology, International Journal of Science Education, Advances in Intelligent Systems and Computing, Heliyon and Plants each contain 2 articles, showing that plant awareness approaches

are now not only discussed from a pedagogical aspect, but also from sustainability and pure biology approaches. The article by Fiel'ardh et al. (2023), for example, shows the integration between Education for Sustainable Development and plant awareness in science teacher education.

Interestingly, there are also some articles that appear in engineering and energy journals such as Nuclear Engineering and Technology and Energy Strategy Reviews. Although thematically not entirely focused on education, these articles are still relevant because they discuss aspects of awareness in the context of plant presence and impacts, for example, in the issue of vegetation disturbance to energy facilities or industrial area conservation (Lee et al., 2022; Sakoda et al., 2021).The wide distribution of journals reflects that plant awareness is no longer the narrow domain of biological sciences or environmental education alone, but has expanded into interdisciplinary domains, including technology education, public health, and even the humanities (de Almeida et al., 2024; Ichim, 2024).

This finding also suggests that there are great opportunities to expand publications in other science-based and environmental education journals. With the increasing interest in sustainability and green education, it can be predicted that journals with a focus on SDGs and ecological education will be a strategic platform for disseminating plant awareness studies in the future.

3. Most Productive Authors and Affiliates

Identifying the most productive authors in plant awareness topics is crucial to understanding who the key figures are who contribute greatly to the development of theories, methods, and research directions. In addition to bibliometric information, this data can also be used as a basis for strengthening academic collaboration networks, both nationally and internationally. These authors are generally pioneers in the development of instruments for measuring plant awareness, integrating this issue in biology education, and advocating for the importance of botanical literacy in science and sustainability education.

Table 3 shows that four key contributors, K.M. Parsley, B.C. Stagg, A. Amprazis, and L. Gutiérrez-García each contributed two articles during the 2020–2025 period. These authors are affiliated with leading institutions such as the University of Memphis, the University of Missouri, the University of Western Macedonia, and the Universidad de Salamanca. Meanwhile, the remaining 54 articles were authored by individuals who each contributed only one publication. These findings indicate that, despite the rapid growth of interest in this topic, the field remains in an early and dispersed stage, with authorship still widely distributed and no single author exhibiting clear dominance.

Table 3. Most Productive Authors

Author Name	Number of Articles
K.M. Parsley	2
B.C. Stagg	2
A. Amprazis	2
L. Gutiérrez-García	2
Other (1 each)	54

Source: Data processed from Scopus publications (2020-2025)

From the analysis, two author names stand out as the most productive contributors to plant awareness research in the context of education, namely K.M. Parsley, B.C. Stagg, A. Amprazis, and L. Gutiérrez-García, each with two articles. K.M. Parsley is noted as a pioneer in redefining the term "plant blindness" to plant awareness disparity, and developing a measurement instrument called the Plant Awareness Disparity Index (Parsley, 2020; Parsley et al., 2022). Meanwhile, B.C. Stagg contributed in the form of an extensive literature review and the development of a conceptual model of plant awareness-based learning (Stagg et al., 2025; Stagg & Dillon, 2022).

Other notable researchers include J. Marcos-Walias, who explored plant awareness at different levels of education in Spain (2023), and S. Guerra, who examined the role of sensory experiences in enhancing plant awareness (2024). While Ahmed et al. (2020) discuss public awareness in the context of energy and plant policy, which, although not directly focused on education, still contributes a perspective on the importance of plant awareness in a social context.

Most of the other authors were involved in only one article, indicating that this topic is still relatively new as a focused area of study. However, this also opens up opportunities for further collaboration, especially among researchers from the fields of education, ecology, and environmental psychology.

Table 4 shows the most productive institutions in publishing articles related to this research topic. The University of Memphis, the University of Missouri, the University of Western Macedonia, and the Universidad de Salamanca each contributed two articles, making them the highest contributing institutions. Meanwhile, several other universities, such as the University of Riau, the University of Vienna, and the University of Leeds, only contributed one article each. This data indicates that scientific contributions in this field are spread across various countries, including Indonesia, but are still dominated by institutions from the United States and Europe.

Table 4. Most Productive Institutions

Institution	Country	Number of Articles
University of Memphis	United States	2
University of Missouri	United States	2
University of Western Macedonia	Greece	2
Universidad de Salamanca	Spain	2
University of Edinburgh	United Kingdom	1
University of Évora	Portugal	1
University of Vienna	Austria	1
Universitas Riau	Indonesia	1
University of Leeds	United Kingdom	1

The most prominent institution is the University of Memphis, where K.M. Parsley is affiliated, which was at the initial center of redefining the concept of plant awareness. This was followed by universities from Spain and Australia that showed involvement in instrument development and public perception studies. Although the number of publications from institutions is still scattered, the presence of contributions from universities on different continents reflects that plant awareness has become a global discourse.

Interestingly, there are several contributions from Indonesia, such as the article by Bakar et al. (2020), which discusses teachers' perspectives in nature education, as well as a 2025 article by M. Kumar, which examines community perceptions of invasive plants in the Himalayas, which also touches on the realm of ecological learning. This opens space for Indonesia to become one of the important players in plant awareness research in the future, given its rich biodiversity and ecological education challenges.

4. Article Trend by Citation

Citation analysis is an important indicator to assess the influence of a publication in the scientific community. Articles that are frequently cited usually have a high contribution value, both in concept development, methodology, and in encouraging discussion and further research. Thus, mapping citation trends allows researchers to identify works that serve as theoretical and methodological foundations in plant awareness studies.

Table 5 shows that K.M. Parsley's 2020 article entitled Plant awareness disparity: A case for renaming plant blindness is the most influential publication with a total of 136 citations. This article conceptually challenges the term "plant blindness" and introduces a new, more inclusive term, plant awareness disparity. Other highly cited articles were by S. Stroud (54 citations) and B.C. Stagg (52 citations), which contributed to the discussion of the link between plant relevance and botanical awareness in educational contexts. The presence of articles from different countries and approaches- quantitative, qualitative, and literature review- illustrates the diversity of approaches in exploring this topic and the importance of cross-disciplinary collaboration.

Table 5. Trend by citation

Number of Citations	Author	Title
136	K.M. Parsley	Plant awareness disparity: A case for renaming plant blindness
54	S. Stroud	The botanical education extinction and the fall of plant awareness
52	B.C. Stagg	Plant awareness is linked to plant relevance: A review of educational and ethnobiological literature (1998–2020)
45	Z. Fang	State Estimation for Situational Awareness of Active Distribution System with Photovoltaic Power Plants
41	B. Cordeiro	Does public awareness about invasive plants pays off? An analysis of knowledge and perceptions of environmentally aware citizens in Portugal
30	P. Pany	Measuring students' plant awareness: A prerequisite for effective botany education

Table 5. Continue...

25	K.M. Parsley	Initial Development and Validation of the Plant Awareness Disparity Index
22	K. Fiel'ardh	Integrating Perspectives from Education for Sustainable Development to Foster Plant Awareness among Trainee Science Teachers: A Mixed Methods Study
21	A. Trewavas	Awareness and integrated information theory identify plant meristems as sites of conscious activity
21	K. Brownlee	An analysis of plant awareness disparity within introductory biology textbook images
17	S. Ahmed	Public awareness and stakeholder involvement for Bangladesh's nuclear power plant
14	F. Schoden	Building a wind power plant from scrap and raising public awareness for renewable energy technology in a circular economy
12	Y. Liu	Methodology for dynamic reliability assessment of team situation awareness of digital nuclear power plants
11	I. Gazoulis	Invasive Alien Plant Species Raising Awareness of a Threat to Biodiversity and Ecological Connectivity (EC) in the Adriatic-Ionian Region
11	Y. Lee	Use of Gaze Entropy to Evaluate Situation Awareness in Emergency Accident Situations of Nuclear Power Plants
10	J. Chodkowska-Miszczuk	A new narrative for sustainability: Exploring biogas plants as 'first movers' in raising energy awareness
8	J. Marcos-Walias	Plant awareness disparity among students of different educational levels in Spain
8	S. Guerra	Plant awareness in the hand
7	E. Solberg	Situation awareness in outage work – A study of events occurring in U.S. nuclear power plants between 2016 and 2020
7	F. Bakar	Plant and animal awareness in nature education perspectives: Where is blindness?

5. Keyword Analysis

Keyword analysis was conducted using VOSviewer software, which produced a network visualization based on the frequency and connectedness of keywords from 62 relevant Scopus-indexed publications in the period 2020-2025. The visualization results show the existence of several thematic clusters that reflect the direction and focus of plant awareness research in learning.

The visualization in Figure 1 below shows the thematic clusters in the keyword network generated using VOSviewer software. Several clusters of interconnected terms were identified, such as awareness, plant, review, and nuclear power plant. Keyword awareness appears to be the central link that bridges the clusters, suggesting that awareness is a central topic in the review of related literature. In addition, there is a link between plant awareness and review, indicating a research focus on the review of plant awareness in specific contexts.

The keyword "awareness" is the center of the network (it is located in the middle and has a large size), indicating that it is a very frequent term and has many connections with other keywords.

a. Thematic Clusters in Keyword Networks

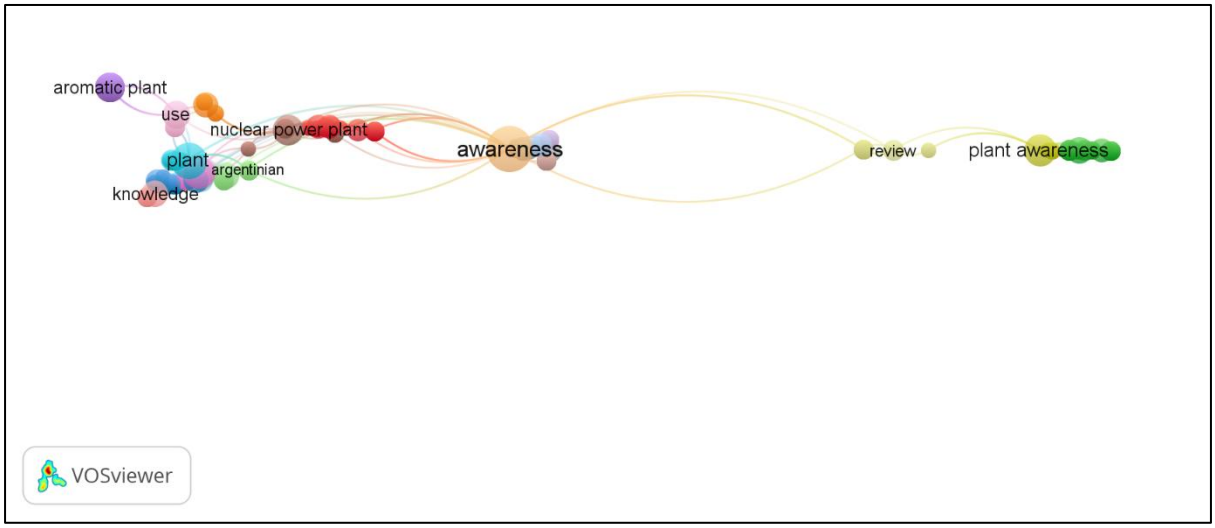

Figure 1. Thematic Clusters in Keyword Network

The red cluster focuses on the theme of nuclear energy and public awareness. Keywords associated with this cluster include 'nuclear power plants,' 'awareness,' and 'knowledge.' Although this cluster is not directly related to educational research, its presence may be attributed to keyword overlap, particularly the use of general terms such as 'awareness' and 'knowledge,' which are also common in plant awareness studies. This overlap indicates the need for more refined dataset curation, especially in filtering publications whose contextual focus differs from educational or biological domains. Nonetheless, this cluster provides insight into how the concept of awareness is used across disciplines, including in energy policy and public science communication. Orange cluster, focusing on the theme of plant utilization and locality. Showing the link between plant use and local or geographical context.

The green cluster focuses on Plant Awareness, which examines awareness of plants, both from a psychological, educational, and philosophical perspective. Topics in this cluster include how humans understand and appreciate plants and the relevance of ecological awareness in philosophy education. The blue cluster focuses on basic plant knowledge with the main keywords "plant" and "knowledge". This theme touches on fundamental aspects of general plant knowledge, botanical literacy, scientific understanding, and early ecological awareness.

b. Emerging Research Focuses

Based on the overlay visualization analysis, it appears that the most recent research (2023-2025) is marked in bright yellow, indicating a trend towards: 1) Development of measurement instruments such as the Plant Awareness Disparity Index (Parsley et al., 2022); 2) The use of innovative and digital media, such as educational games (Chisalita, 2022) and digital humanities (de Almeida et al., 2024). 3) Transdisciplinary approaches, such as integration with Education for

Sustainable Development (Fiel'ardh et al., 2023), cross-cultural botanical literacy, and citizen science (Forti & Szabo, 2024).

Figure 2 presents the evolving research focus based on the temporal distribution of keywords in the thematic network. The colors in the visualization reflect the period of topic occurrence, ranging from dark blue (2021) to bright yellow (2024). It can be seen that terms such as knowledge, aromatic plants, and use appear early, while terms such as review and plant awareness are more dominant in recent years. This indicates a shift in research attention from conceptual and technical aspects towards critical review and awareness of plants as objects of study. The role of word awareness remains the thematic center that connects these developments across time.

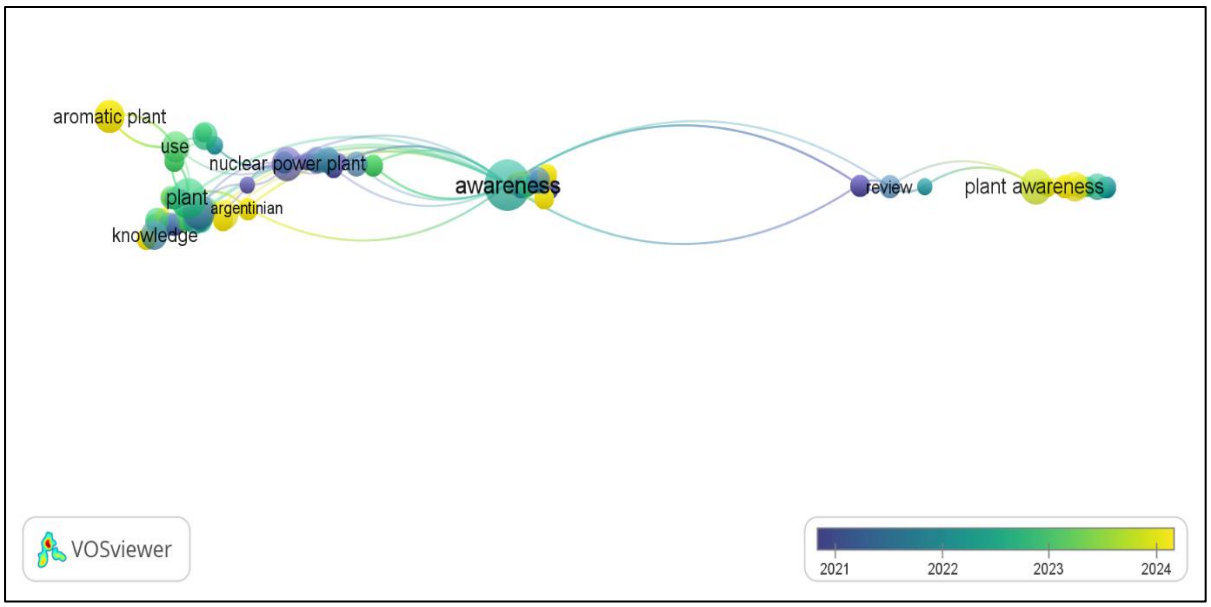

Figure 2. Emerging Research Focuses

This trend indicates that the topic of plant awareness has transcended traditional approaches and is now expanding into the realm of innovative, participatory, and local and global solutions-based education.

c. Implications of Keyword Findings

This mapping shows that plant awareness is no longer seen as just biological awareness, but as a dimension of critical ecological education that touches on aspects of perception, culture, and sustainability. Plant education needs to be contextualized and rooted in students' local environment, given that keywords such as ethnobotany, indigenous plants, and local knowledge are starting to appear in recent publications.

Discussion

Bibliometric analysis confirms that *plant awareness* has emerged as a significant and rapidly evolving research area within science, environmental, and sustainability education. Although

scholarly attention has intensified over the past five years, the thematic landscape reveals a multidimensional and methodologically diverse body of knowledge. This growth reflects a broader shift in environmental education, moving from abstract ecological concepts toward more grounded, inclusive, and transformative educational practices.

One of the most notable developments is the terminological evolution from *'plant blindness' to 'plant awareness disparity'*. This shift from a deficit-based diagnosis to a solutions-oriented framework signals a critical reframing of how educational interventions should be designed. Recent works (e.g., Parsley et al., 2022; Stagg et al., 2025) advocate for terminologies that not only diagnose student disinterest but also offer measurable and pedagogically relevant alternatives. This conceptual shift positions plant awareness not merely as a cognitive gap, but as a teachable, assessable, and ethically grounded competence, an insight that previous literature tended to overlook.

A second cluster of research emphasizes humanistic and contextualized learning strategies. Unlike traditional didactic approaches, these studies (e.g., Forti & Szabo, 2024; Marcos-Walias et al., 2023) highlight the role of place-based learning and ethnobotany in fostering ecological empathy. What distinguishes these findings is the consistent evidence that linking botanical content to local knowledge and student identity leads to deeper emotional and cognitive engagement, a clear divergence from earlier models that treated plant learning as culturally neutral or universally transferable.

The visual dimension of botany education also emerges as a critical area of concern. Several studies have revealed persistent underrepresentation and stereotypical portrayals of plants in textbooks (Brownlee et al., 2023), echoing previous critiques while extending them through empirical analyses of student perceptions and media use. The rise of interactive and digital tools from botanical illustrations to educational games (Chisalita et al., 2022; de Almeida et al., 2024) marks a methodological innovation that previous studies had not systematically explored.

Moreover, the intersection of plant awareness and sustainable education signals an important transdisciplinary shift. Research, such as that by Fiel'ardh et al. (2023), positions plant awareness as a foundational element of Education for Sustainable Development (ESD), challenging earlier views that saw it as a niche topic within biology. The ability of plant awareness to bridge science education, environmental ethics, and sustainability literacy suggests broader applications than previously recognized.

Instrument development represents another breakthrough. Tools such as the Plant Awareness Disparity Index (Parsley et al., 2022) and demographic-based measurement scales (Linderwell et al., 2024; Pany et al., 2024) enable the systematic evaluation of plant-related attitudes and knowledge. This formalization sets the groundwork for comparative studies and curriculum benchmarking something missing in earlier qualitative research traditions.

However, this review also surfaces several critical gaps. First, despite the global framing of plant awareness, countries with high biodiversity, such as Indonesia, Brazil, and the Philippines, remain underrepresented in authorship and thematic coverage. This is surprising given that such contexts offer rich cultural and ecological material for advancing plant-focused education. Second, the integration of plant awareness into national curricula remains limited, with most interventions relying on isolated projects rather than systemic reforms. Third, the connection between plant awareness and actual conservation behaviors remains poorly understood, underscoring the need for interdisciplinary, action-based research.

In response to these challenges, this article offers a novel perspective by mapping the structural development of plant awareness research, while also highlighting the absence of contributions from megadiverse countries such as Indonesia. This raises important questions: Why has Indonesia, with its vast botanical resources and strong cultural traditions surrounding plants, not yet emerged as a leader in this field? And how might Indonesia's local wisdom, such as ethnobotanical knowledge or customary forest practices, enrich global dialogues on plant education?

By synthesizing current trends and identifying both opportunities and limitations, this study offers a roadmap for future inquiry. It positions *plant awareness* not as an isolated educational trend but as an emerging scientific and pedagogical movement with implications for biodiversity conservation, sustainability education, and cross-cultural understanding. The findings also offer practical value for curriculum developers, particularly in the Global South, who seek culturally relevant and ecologically grounded learning models.

In summary, the study advances the literature by providing a comprehensive, data-driven overview of plant awareness research, while simultaneously advocating for stronger participation from underrepresented regions, particularly Indonesia. By situating plant awareness as both a global concern and a local opportunity, this article contributes to the theoretical and practical reimagining of how plants are taught, valued, and conserved through education.

CONCLUSION

This topic has undergone a paradigm shift from deficit narratives, such as plant blindness, to constructive and solution-oriented approaches in the form of plant awareness disparity. In addition, the findings also show that research tends to lead to the development of measurement instruments, the application of technology and media in botany learning, and the integration of sustainability values through the Education for Sustainable Development approach. On the other hand, several challenges remain, including limited cross-country collaboration, a lack of explicit curriculum related to plant awareness in many education systems, and low local involvement in biodiversity-based research. This research is expected to serve as a foundation for academics,

educators, and policymakers in developing more effective, reflective, and contextualized learning strategies that foster students' ecological awareness through learning about plants. With a transdisciplinary and locally based approach, plant awareness can be the key to a more sustainable future in education.

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