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Ecoliteracy competencies: A systematic literature review of domains, approaches, and impacts in education

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Abstract

Ecological education is often regarded as a supplementary topic, limiting access to ecological materials and hindering the development of ecoliteracy. This study systematically reviews 40 Scopus-indexed articles (2015-2024) using PRISMA methodology and thematic analysis to explore the domains, approaches, and impacts of ecoliteracy in education. Five key domains are identified: ecological knowledge, critical thinking, environmental awareness, practical application, and active participation. Effective approaches, such as experiential learning, are highlighted as empowering strategies that connect education to real-world experiences and foster critical engagement with environmental issues. This study underscores the importance of integrating ecoliteracy into formal curricula to build competencies for addressing global ecological challenges. As a key contribution, the research provides evidence-based recommendations for enhancing ecoliteracy globally, offering a foundation for developing educational policies that support sustainable learning. The findings are globally relevant, providing new directions for both research and educational practice.

Keywords: ecoliteracy, domains, approaches, impacts

INTRODUCTION

Technological advances in the modern era increase the importance of ecoliteracy, especially in the face of global challenges such as climate change, biodiversity loss, and pollution that threaten the earth (Lovren & Jablanovic, 2023). Ecoliteracy is the ability to understand the relationship between humans and the environment, and the impact that human actions have on nature. This concept includes knowledge of ecological principles, such as biodiversity, natural cycles and the limitations of natural resources (Lopez-Leon & Encino-Muñoz, 2020; Sharma, 2023). Ecoliteracy also provides an understanding of the relationship between humans and nature, encouraging people to support environmental policies, choose sustainable lifestyles, and actively participate in conservation (Firinci Orman, 2024; Kiewra et al., 2023). These efforts also emphasize the importance of protecting endangered species and balancing ecosystems for future generations (Ma et al., 2023). The current environmental crisis reinforces the urgency of ecoliteracy to maintain sustainability, understand the impact of human activities on ecosystems, and support climate mitigation and adaptation measures (Gan et al., 2021; Wierzbiński et al., 2021). This knowledge drives concrete actions such as reducing plastics, supporting renewable energy, and sustaining natural resources for the future (Ardoin et al., 2020; Datu & Buenconsejo, 2021). In addition, ecoliteracy is important in teaching how to utilize technology to support environmental sustainability (Cavalinhos et al., 2021; Reamer, 2023). With this knowledge, people can use technologies such as renewable energy, sustainable agricultural practices, and efficient waste management to reduce negative impacts on the earth (Czajkowska & Ingaldi, 2023). Ecoliteracy, which is relevant to the needs of the times, educates people about the importance of mitigation and adaptation to climate change so that people can survive and actively contribute to overcoming the climate crisis (Hui et al., 2023). By integrating ecoliteracy values into education and daily life, the global community can move towards a more sustainable future in harmony with nature (Ballard et al., 2024; Billore & Anisimova, 2021).

Environmental education often treats environmental literacy and ecoliteracy as similar concepts, yet they

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Contribution to the literature

- This article reviews and analyzes the literature on eco-literacy, covering its domain, approaches, and impact in education as a basis for developing a deeper understanding of environmental issues, improving the quality of education, and shaping practical skills in sustainability.
- This systematic literature review (SLR) is limited to original articles, restricting the scope of the research to specific research topics or themes.
- The development of the domain, approaches, and impact in education aims to deepen the understanding of eco-literacy, integrate effective approaches, and enhance its impact on the quality of education and practical skills in environmental sustainability.

emphasize different aspects. Environmental literacy generally refers to an individual's capacity to understand environmental issues, maintain a positive attitude towards the environment, and demonstrate environmentally friendly behaviors. This approach focuses more on the aspects of knowledge, attitude, and individual actions, and is often measured through cognitive and behavioral indicators (Arif et al., 2025; Gatan et al., 2021; Goulgouti et al., 2019; LeSage-Clements et al., 2024; Svobodová & Kroufek, 2022). In contrast, ecoliteracy emerges from systems thinking in ecology and emphasizes the reciprocal relationship between humans and nature. This concept encompasses not only ecological understanding but also ethical, emotional, and transformative dimensions that encourage active engagement in creating sustainable communities (Kim et al., 2017; Lopez-Leon & Encino-Muñoz, 2020; Nawawi & Wardhani, 2023; Sigit et al., 2023; Valenzuela-Chapetón, 2023). Therefore, ecoliteracy is viewed as a more comprehensive framework for sustainability education, integrating critical awareness, empathy towards nature, and reflective practices in everyday life.

The importance of ecoliteracy in education, both formal and informal, is undeniable in shaping strong environmental awareness in future generations (van de Wetering et al., 2022). In formal education settings such as schools and universities, ecoliteracy can serve as a knowledge base for students to understand the impact of human activities on the environment (Carbonell-Alcocer et al., 2023). Through a curriculum that includes ecological materials, students can learn about important concepts such as biodiversity, ecosystem cycles, and finite natural resources (Ardoin et al., 2023). It helps students see the environment as an integral part of their lives and understand that preserving nature is a shared responsibility that must be fulfilled for mutual well-being (Abdullah, 2023). Formal education also allows for the direct application of ecoliteracy practices through laboratory experiments, research projects, and outdoor activities (Powell et al., 2023). For example, students can be invited to conduct field studies to observe the impacts of climate change or recycling practices in the school environment (Gazoulis et al., 2022). Such experiential learning can foster a deeper sense of caring and encourage students to think of innovative solutions to environmental problems (Hussain & Huang, 2022). In this way, ecoliteracy becomes an important provision for the younger generation to think critically and develop sustainable solutions.

Informal education in families, communities, and social environments also significantly spreads ecoliteracy values (Lovren & Jablanovic, 2023).In informal contexts, ecoliteracy learning can be done through simple daily activities, such as reducing plastic waste, utilizing renewable energy, or keeping the surrounding environment clean (Hui et al., 2023). Parents and other community members can be role models who inspire the younger generation to live more environmentally friendly lives (Tiwari, 2023). This informal education helps to create a strong culture of environmental care so that every individual in the community grows up with a deep ecological awareness and is ready to contribute to maintaining environmental sustainability (Kūlnieks, 2023).

The integrative and applicative characteristics of ecological learning strongly support efforts to integrate ecoliteracy into daily life (Lin et al., 2022). Ecological learning focuses on theory and emphasizes the importance of hands-on experiences, such as field practices, experiments, and nature observation (Wu et al., 2020). Through this approach, individuals gain a more tangible understanding of how human activities affect the environment and what can be done to keep ecosystems in balance (Botella et al., 2022). For example, students who learn about the water cycle and the impact of water pollution will better understand the importance of keeping rivers and other water sources clean, which can be applied to daily habits (Galli et al., 2020). In addition, the interdisciplinary nature of ecological learning introduces concepts from various fields, such as biology, geography, chemistry, and sociology, to provide a comprehensive picture of the ecosystem (Ardoin et al., 2020). This lets individuals see that every aspect of life is connected and impacts the environment, from daily consumption choices to energy patterns. By understanding these interconnections, individuals can develop more environmentally conscious lifestyles, such as using less plastic, recycling, and supporting ecologically friendly products. Thus, the learning

characteristics of ecology play an important role in shaping a generation that is not only environmentally minded but also able to apply ecoliteracy principles in daily life for the earth's sustainability.

Although integrating ecoliteracy into daily life is crucial, various challenges exist in developing ecoliteracy competencies in society (Ardoin et al., 2018). One of the main challenges is the lack of awareness and deep understanding of environmental issues among the general public. Ecological education is often seen as an additional topic rather than a core element of the formal education curriculum, so limited access to ecological materials and learning hinders the development of ecoliteracy competencies (Schneller et al., 2021). In addition, the lack of training and facilities for field activities and direct observation makes it difficult for students to apply ecological theory in real situations (Dale et al., 2020).

Another challenge is resistance to greener lifestyle changes, often perceived as inconvenient or expensive (Powell et al., 2023). For example, reducing plastic waste or choosing environmentally friendly products still requires more effort and sometimes higher costs. This factor can be a barrier, especially among people who do not have a strong awareness or commitment to the environment (Clark et al., 2020). In addition, challenges in technological development and social media can also be a double-edged knife. On the one hand, technology can help disseminate ecoliteracy information quickly, but on the other hand, information that is inaccurate or not supported by scientific data can cause misinformation (O'Hare et al., 2020). Therefore, a comprehensive strategy is needed to address these challenges so that ecoliteracy competencies can flourish and become an integral part of people's lives (Ardoin et al., 2015).

The results of the previous systematic literature review (SLR) studies on ecological literacy show increasing attention to the importance of ecoliteracy at various levels of education and society (Ardoin et al., 2018). These studies identified that ecological literacy is strongly related to the formation of environmental awareness, increased knowledge about ecosystems, and the development of proactive attitudes toward nature conservation (Schneller et al., 2021). In general, research shows that individuals with higher levels of ecoliteracy tend to have a better understanding of the linkages between human activities and their environmental impacts, which in turn encourages them to take sustainable actions, such as reducing waste, supporting renewable energy, and conserving biodiversity (Dale et al., 2020).

Previous SLR research shows significant differences in the effectiveness of ecology learning based on the methods used. Hands-on experiential methods, such as field projects and nature observation, are more effective in improving ecological understanding than lectures or theoretical approaches (Powell et al., 2023). However, research also reveals that there are still limitations in implementing these learning methods, especially in areas that have limited access to ecological education resources and facilities (Clark et al., 2020). Overall, these SLR studies emphasize the importance of integrating ecological literacy into the curriculum and the importance of government and institutional support to provide adequate learning tools to improve ecoliteracy competencies among communities (Ardoin et al., 2015).

The objectives of this SLR provide in-depth insight into how ecoliteracy competencies are divided into several key domains, such as ecological knowledge, environmental awareness, critical thinking skills, practice, and active participation of learners. This categorization was done based on the main findings of the selected articles, namely ecological knowledge includes understanding ecological principles such as biodiversity, natural cycles, and the limitations of natural resources, as well as the impact of human activities on the environment. Critical thinking skills in ecoliteracy involve the ability to analyze environmental issues and assess the impact of policies or actions on nature. Environmental awareness is the attention to environmental issues such as climate change and pollution, as well as the importance of maintaining ecosystem balance. Ecoliteracy practices focus on applying knowledge in everyday life, such as saving energy, reducing waste, and supporting sustainable agriculture. Active participation of learners means involvement in activities or initiatives aimed at protecting the environment, such as environmental organizations or conservation projects, to become agents of change in nature conservation. This research maps out in more detail the specific elements that need to be developed in the education system to shape environmentally minded individuals. By identifying and categorizing these domains, this article will contribute significantly to directing learning strategies and educational curricula to focus more on the essential aspects to create a generation competent in environmental issues. In addition, the novelty value of this article also lies in analyzing the impact of various ecological education methods on ecoliteracy competence. This article evaluates the educational approaches implemented and measures their effectiveness in improving students' ecoliteracy. The article presents trends and patterns in the literature and provides evidence-based recommendations for improving ecoliteracy teaching. This conclusion is important in the context of the increasing urgency of environmental issues, where this article can give practical guidance for educational institutions and policymakers in designing curricula that are relevant and responsive to current global environmental challenges.

METHOD

This research is a qualitative study using a SLR approach that systematically collects, evaluates, and synthesizes previous research results related to ecoliteracy in education (Ardoin et al., 2018). This SLR helps identify relevant patterns and trends and discover gaps in existing research, thus opening up opportunities for innovation and further development (Schneller et al., 2021). SLR research in education is important for developing a deep and evidence-based understanding of educational issues (Clark et al., 2020).

Literature Review

This study involved a literature review of the Scopus database, a credible database source, a selection of articles based on strict inclusion and exclusion criteria, and systematic analysis (Aghaei Chadegani et al., 2013; Norris & Oppenheim, 2007). This study used the PRISMA guidelines, a protocol proposed by (Moher et al., 2009) for reporting systematic reviews. The use of PRISMA in this study is considered appropriate because this protocol is widely recognized and strictly followed in many studies. According to Panic et al. (2013), the quality of reporting and methodology is higher in journals that use PRISMA than those that do not. PRISMA is also widely applied in business and marketing (Siddaway et al., 2024; Ter Huurne et al., 2017). PRISMA's wide application and recognition increase the chances of this research being accepted and published. Although PRISMA is not the newest method, it remains a valid and reliable protocol for systematic reviews, including the SPAR-4-SLR method up to the fourth stage (Sauer & Seuring, 2023). This method is still effective for conducting a comprehensive literature search and selecting relevant articles for review, according to the purpose of this article. According to Hariningsih et al. (2024), Rehman et al. (2020), Riedel et al. (2022), and Rincon-Novoa et al. (2022), the steps in this SLR are as follows:

1. Identify keywords, criteria, and limitations,
2. Screening for relevant articles,
3. Searching for articles from the selected studies and considering exclusions,
4. Reading titles, abstracts, and keywords of selected articles,
5. Filling in the paths and items of each article in the data extraction process,
6. Performing classification analysis and data visualization.

A systematic and comprehensive literature review can be produced by this research using these steps. The keywords used in the literature search were environmental education outcomes, ecological awareness, and environmental awareness. By using these keywords, the research can reach relevant studies related to domains, approaches, and Impacts in Education. The steps taken in the SLR can be seen in **Figure 1**.

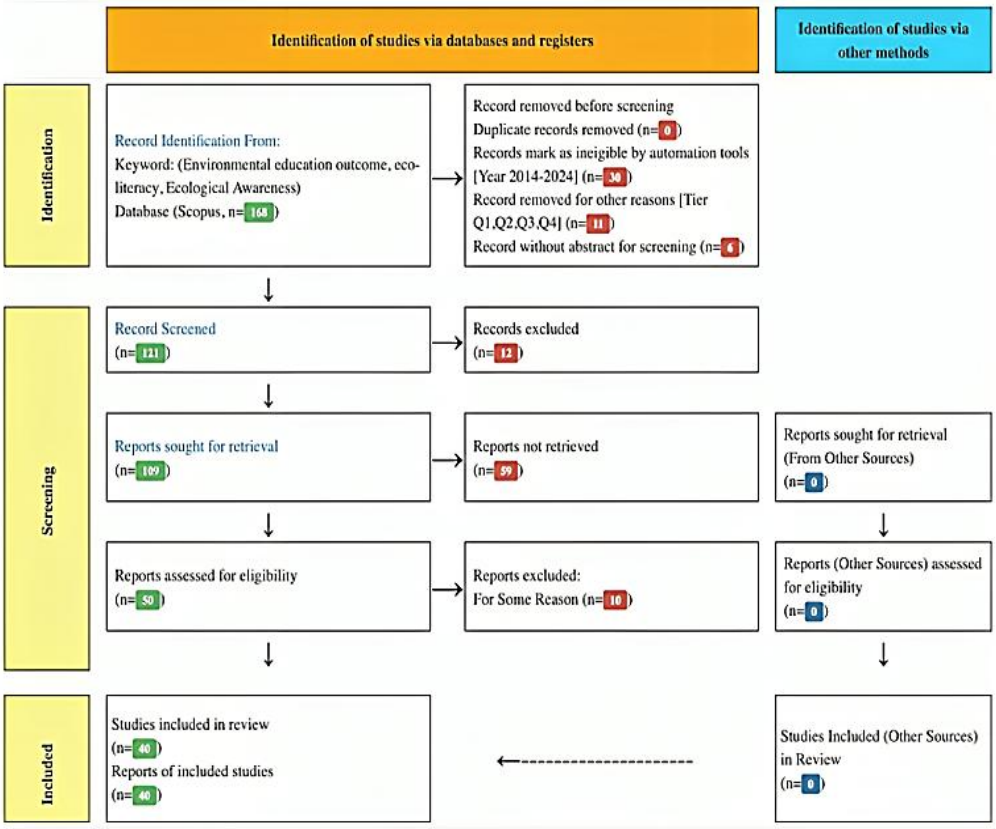

Figure 1. Identification, screening, and inclusion steps (Source: Authors' own elaboration)

The systematic review process in this study was conducted in 6 steps.

Step 1. Identification of keywords, criteria, and restrictions: In the first step, we started with the identification of articles from the Scopus database using keywords such as environmental education outcome, ecoliteracy, and ecological awareness, resulting in 168 articles. These keywords were selected in this SLR because each represents an important aspect of ecoliteracy education. Environmental education outcome focuses on the outcome or impact of environmental education, allowing the review to explore the extent to which environmental education influences changes in learners' attitudes, behaviors, and knowledge related to ecological issues. Ecoliteracy becomes the main keyword as it highlights the competencies that individuals must have to understand, appreciate and sustainably interact with the environment, covering aspects of knowledge, skills and awareness that are important in creating a deeper environmental awareness. Meanwhile, ecological awareness is relevant as it describes learners' level of awareness of ecological issues and the importance of environmental conservation and helps explain how education can shape individuals' understanding of the impact of human actions on ecosystems. These three keywords strengthen the review to explore the various domains, approaches and impacts of ecoliteracy education in shaping learners' ecoliteracy competencies.

Step 2. Screening articles: Once the keywords were established, the next step was to set inclusion and exclusion criteria to ensure only relevant articles were included in this review. Screening of articles from the Scopus database found through the keyword search was organized. The screening process began by evaluating articles based on a predetermined time span, which was from 2014 to 2024. Articles published before 2014 were excluded to ensure that the review relied on current research relevant to the latest developments in the field of ecoliteracy education. Furthermore, articles published in journals beyond Q1-Q4 were also removed as we only considered articles published in highly reputable journals to maintain the quality of this review. In addition, articles that did not include an abstract or were simply opinion pieces without clear data were also excluded. This was important to ensure that only articles with clear methodology and relevant data were considered. This screening process reduced the number of articles from 168 to 121 that met the initial criteria. This screening stage was critical to ensure that the articles selected were truly relevant to the topic and purpose of this systematic review.

Step 3. Eligibility assessment: At this stage, the 121 screened articles were subjected to an eligibility assessment to assess the appropriateness of the articles' content to the topic of this review. The assessment process began by reading the title and abstract of each article to ensure that the article actually addressed the outcomes or impacts of ecoliteracy education, as well as the approaches used in teaching ecoliteracy. Articles that were not directly related to this topic or that only touched on aspects of education in general were excluded from the list. In addition, we also checked whether the articles used clear and reliable methodologies, such as empirical studies or data-driven analysis. Articles that did not meet the criteria of a valid methodology or that were too general without strong analysis were filtered out. Of the 121 articles, 12 were removed because they were deemed irrelevant or did not meet the quality standards. In the end, only 109 articles remained for further evaluation.

Step 4. Report capture and feasibility evaluation: With 109 articles remaining, the next step was to conduct a report retrieval to evaluate their eligibility. Of the 109 available articles, only 50 articles were successfully retrieved and fully accessed. Retrieval was done with the aim of ensuring that the articles could actually be evaluated in depth and could contribute to this review. Some articles could not be accessed due to technical issues or access rights constraints, which resulted in 59 articles not being retrieved for further assessment. In this process, it was important to ensure that the retrieved articles were fully accessible, so that the data and information obtained could be analyzed in detail. Inaccessible or incomplete articles could not be used for further review. After retrieval, we proceeded with an eligibility assessment of the successfully accessed articles to ensure that these articles actually met the eligibility criteria.

Step 5. Final feasibility assessment: At this stage, a more in-depth eligibility assessment was conducted on the 50 retrieved articles. This assessment involved two main criteria, namely the relevance of the article to the research topic and the quality of the methodology used in the study. Articles that did not meet the eligibility criteria, such as those that did not include relevant data or lacked a clear methodology, were excluded from this review. Of the 50 retrieved articles, 10 articles were excluded at this stage as they were deemed irrelevant or did not meet the predetermined eligibility standards. Therefore, only 40 articles were retained and included in the final review. This reduction in the number of articles was the result of a rigorous screening process and highly selective eligibility assessment, which aimed to ensure that only high-quality articles were used in this review.

Step 6. Compilation of literacy review and analysis: With 40 articles remaining, the final step was to compile a comprehensive literature review. At this stage, the screened articles were analyzed to understand the different approaches, domains and impacts of ecoliteracy education. This includes evaluating the methodologies used, key findings and how ecoliteracy education can shape learners' competencies in terms of ecological knowledge, skills and awareness. The

Table 1. Ecoliteracy competency domains

No	Ecoliteracy competency domains	Count	References
1	Knowledge, critical, awareness, practical, participation	16	Abdullah (2023), Carbonell-Alcocer et al. (2023), Czajkowska and Ingaldi (2023), Kiewra et al. (2023), Ma et al. (2023), Ardoin (2022), Ardoin et al. (2023), Powell et al. (2022), van et al. (2022), Ardoin et al. (2020), Powell et al. (2019), Schneller et al. (2019), Ardoin et al. (2018), Ardoin (2015), Flowers et al. (2014), West (2014)
2	Knowledge, awareness, practical, participation	7	Ballard et al. (2024), Firinci (2024), Botella et al. (2022), Gazoulis et al. (2022), Ricoy and Sánchez-Martínez (2022), Tiwari (2022), Wu et al. (2020)
3	Awareness, practical, participation	6	Lin et al. (2022), Datu and Buenconsejo (2021), Dale et al. (2020), Galli et al. (2020), O'Hare (2020), Gąbiński (2015).
4	Awareness, participation	5	Sprague et al. (2022), Wierzbinski et al. (2021), Clark et al. (2020), Szczytko et al. (2018), Stern et al. (2017)
5	Knowledge, awareness	2	Pearce (2024), Glbiński (2015)
6	Knowledge, critical, awareness, practical	2	Hui et al. (2023), Gan et al. (2021)
7	Knowledge, awareness, practical	2	Pearce (2024), Lovren and Jablanovic (2023)

purpose of this literature review is to summarize trends in research, identify gaps, and provide recommendations for future research. Using 40 rigorously selected articles, this review provides a valid and reliable analysis of how ecoliteracy education can affect learners and its impact on their ecological understanding and awareness. The number of articles selected is also in line with the standard suggested by Paul et al. (2021), who suggests that a minimum of 40 articles is required to achieve sufficient depth in a systematic review.

Data Analysis

This study uses the thematic analysis method to identify the competency domains, approaches, and impacts of ecoliteracy. The researcher further explores the findings through thematic analysis to understand the main patterns and themes that cover the competency domains, educational approaches, and impacts. This process enabled a more comprehensive identification of the themes that emerged in each article, providing a clear picture of the various aspects of ecological literacy (Cavalinhos et al., 2021; Powell et al., 2023). Furthermore, a synthesis of the themes found was used to explore gaps in the domains of competence, approach, and impact in each study (Bhatia et al., 2021). Thus, this analysis not only highlights existing elements but also identifies areas that require further attention in ecoliteracy research (Dale et al., 2020). In systematic review research, clear inclusion and exclusion criteria are essential to ensure that articles are selected objectively so that only relevant and quality studies are selected (Ardoin et al., 2015). A comprehensive literature search used proven software and relevant keywords to capture studies related to the review topic (Powell et al., 2023). In addition, the process involved a team of independent reviewers, which reduced subjective bias and ensured the review results were more reliable (Clark et al., 2020). All selection decisions and rationale are well documented, making the screening process traceable and accountable (Schneller et al., 2021). In this way, researchers can minimize bias, supporting methodological integrity and strengthening the reliability of findings in systematic review research (Hariningsih et al., 2024).

Research Question

Research questions play an important role in determining the scope and focus of a research effort. These questions are formulated:

RQ1. What domains of competence in ecoliteracy can be identified?

RQ2. What approaches have been used in education to develop ecoliteracy?

RQ3. What is the impact of these approaches on ecoliteracy education?

RESULT

Domain of Ecoliteracy Competence

A total of 40 articles have been analyzed, and the categories of ecoliteracy competence domains are presented in **Table 1**. **Table 1** illustrates the different categories that cover elements of ecoliteracy competence, such as knowledge, critical thinking, awareness, practical skills, and participation. Each category reflects the number of studies covering each aspect and references to contributing research in that domain. This classification provides an overview of the research focus on ecoliteracy. It shows the distribution of competency elements among studies, thus facilitating an understanding trends and directions in developing ecoliteracy competencies. We collected the ecoliteracy competency domains from the screened articles in **Table 1**.

The ecoliteracy domain classification data in **Table 1** shows the variation of focus in the analyzed studies, where one study contains more than one domain.

Table 2. Approaches in education to develop the ecoliteracy domain

No	Approach	Count	References
1	Experiential learning	19	Firinci (2024), Pearce (2024), Czajkowska and Ingaldi (2023), Hui et al. (2023), Kuļnieks (2023), Kiewra et al. (2023), Lovren and Jablanovic (2023), Reamer (2023), Sprague et al. (2022), Dale et al. (2020), O'Hare (2020), Powell et al. (2019), Schneller et al. (2019), Szczytko et al. (2018), Ardoin et al. (2018), Stern et al. (2017), Ardoin (2015), Flowers et al. (2014), West (2014).
2	Collaboration with local communities	7	Ballard et al. (2024), Gazoulis et al. (2022), Lin et al. (2022), Tiwari (2022), Wierzbinski et al. (2021), Clark et al. (2020), Galli et al. (2020).
3	Project-based education	6	Carbonell-Alcocer et al. (2023), Ma et al. (2023), Botella et al. (2022), Powell et al. (2022), Ardoin et al. (2020), Wu et al. (2020).
4	Integrated curriculum	4	Ardoin (2022), Ardoin et al. (2023), van et al. (2022), Datu and Buenconsejo (2021).
5	Targeted campaigns and information	2	Gan et al. (2021), Glbiński (2015).
6	Digital technology	2	Abdullah (2023), Ricoy and Sánchez-Martínez (2022).

Ecological knowledge

Knowledge forms the basis of ecoliteracy competencies that include an understanding of environmental issues and concepts related to sustainability. A total of 30 studies included the knowledge element as an integral part of ecoliteracy competencies, making it an important component of ecoliteracy education. These studies emphasized the importance of providing a strong knowledge base on ecosystems, impacts of climate change, as well as sustainability principles to build deep ecological awareness.

Critical thinking skills

Critical thinking focuses on the ability to objectively analyze and evaluate information related to environmental issues. A total of 18 studies included critical thinking as part of the ecoliteracy competency element. The emphasis on critical thinking aims to encourage learners to think analytically and critically about the environmental challenges they face, and to make informed and impactful decisions.

Environmental awareness

Awareness is an important element in ecoliteracy competency, which relates to an individual's understanding of the impact of human actions on the environment and ecosystems. A total of 40 studies consider awareness as an integral part of developing ecoliteracy. By fostering awareness, learners are expected to be able to see the link between their behavior and global environmental conditions, underlying more environmentally friendly behavioral changes.

Practical skills

Practical skills involve the ability to implement ecological knowledge and awareness in daily practices, such as managing natural resources sustainably, reducing waste and engaging in environmental conservation activities. A total of 33 studies included practical skills as part of ecoliteracy competencies. The development of these skills aims for learners to not only understand the theory but also be able to apply it in real life, making a positive impact on the environment.

Active participation

Participation is an aspect that describes the active involvement of individuals in concrete actions to maintain environmental sustainability. A total of 34 studies incorporated the element of participation as an important part of ecoliteracy development. This includes direct contributions to conservation activities and environmental campaigns, which motivate learners to be directly involved in nature conservation efforts.

Approaches in Education to Developing Ecoliteracy

This SLR determines the approaches present in each article by identifying the educational approaches used to develop ecoliteracy competencies. **Table 2** displays the different educational approaches to enhance students' ecoliteracy on ecological issues.

There are many terms used by the researchers in the 40 articles analyzed to describe the approaches used, but the authors grouped them into six categories based on similar principles and characteristics. The educational approaches found are divided into several main categories, namely.

Experiential learning approach

Articles included in this category focus on learning that emphasizes hands-on experience as the core of the learning process. These articles often include teaching methods that invite students to learn through practical activities, such as direct observation of natural phenomena, environmental experiments or field activities that allow students to gain real-world experience. Experiential learning was noted in 19 studies, which emphasized the importance of direct engagement in learning to deepen ecoliteracy understanding.

Table 3. Impact of these approaches on ecoliteracy education

No	Approach	Impact	Count	References
1	Experiential learning	Knowledge, critical, awareness, practical, participation	19	Firinci (2024), Pearce (2024), Czajkowska and Ingaldi (2023), Hui et al. (2023), Kuļnieks (2023), Kiewra et al. (2023), Lovren and Jablanovic (2023), Reamer (2023), Sprague et al. (2022), Dale et al. (2020), O'Hare (2020), Powell et al. (2019), Schneller et al. (2019), Szczytko et al. (2018), Ardoin et al. (2018), Stern et al. (2017), Ardoin (2015), Flowers et al. (2014), West (2014).
2	Collaboration with local communities	Awareness, practical, participation	7	Ballard et al. (2024), Gazoulis et al. (2022), Lin et al. (2022), Tiwari (2022), Wierzbinski et al. (2021), Clark et al. (2020), Galli et al. (2020).
3	Project-based education	Awareness and participation	6	Carbonell-Alcocer et al. (2023), Ma et al. (2023), Botella et al. (2022), Powell et al. (2022), Ardoin et al. (2020), Wu et al. (2020).
4	Integrated curriculum	Critical, awareness, practical, participation	4	Ardoin (2022), Ardoin et al. (2023), van et al. (2022), Datu and Buenconsejo (2021).
5	Targeted campaigns and information	Knowledge and awareness	2	Gan et al. (2021), Glbiński (2015).
6	Digital technology	Knowledge, cractical, participation	2	Abdullah (2023), Ricoy and Sánchez-Martínez (2022).

Collaboration with local communities

Articles that focus on developing ecoliteracy through collaboration with local communities will be included in this category. If an article describes how schools collaborate with community organizations, conservation groups, or other parties in the community to implement programs related to environmental conservation or natural resource management. This approach was applied in 7 studies, which showed that collaboration with local communities can enrich the learning process with real perspectives and experiences from the community.

Project-based education approach

Articles using a project-based education approach will point to teaching that engages students in long-term projects aimed at solving real ecological or environmental problems. These articles typically describe activities that facilitate students to work in teams to design, plan and execute projects dealing with environmental issues. Noted in 6 studies, project-based education focuses on developing practical skills through direct involvement in projects related to environmental issues, allowing students to apply their knowledge in a real context.

Integrated curriculum approach

This approach is found in articles that incorporate ecoliteracy concepts into various subjects or fields of study in a holistic manner. In articles using this approach, ecoliteracy is not taught as a separate subject, but is inserted into other subjects, such as science, math, or art, to provide a cross-disciplinary perspective on ecological issues. The integrated curriculum approach was found in 4 studies, suggesting that this approach allows students to understand environmental issues holistically through various disciplines.

Targeted campaigns and information approach

Articles included in this category tend to discuss the use of campaigns that specifically target specific audiences, either through offline or online platforms, with the aim of delivering important messages related to environmental issues. A total of 2 studies, which show that targeted campaigns can raise awareness of ecoliteracy through media that are broader and more accessible to the public.

Digital technology approach

Articles in this category utilize digital technology as the primary means of disseminating information and education on environmental issues. This includes the use of social media platforms, mobile applications, or websites that provide educational resources and interactive information related to ecology and sustainability. A total of 2 articles discussed this approach.

Impact of the Approaches in Ecoliteracy Education

The approaches used in ecoliteracy education significantly impact students' understanding, awareness, and involvement in environmental issues. We collected the approaches used in ecoliteracy education from the screened articles in **Table 3**.

The data in **Table 3** shows the various approaches in environmental education that contribute to improving ecoliteracy domains. Experiential learning stand out as they cover five main domains: knowledge, critical thinking skills, awareness, practical skills, and participation. Collaboration with local communities focuses on raising awareness, developing practical skills, and promoting participation. Project-based education prioritizes raising awareness and participating in pro-environmental activities. The integrated curriculum

approach includes critical thinking skills, awareness, practical skills, and participation. Targeted campaigns and information mainly increase knowledge and awareness. Meanwhile, digital technology covers all five domains of ecoliteracy, emphasizing learning, critical thinking skills, awareness, practical skills, and participation.

DISCUSSION

Ecoliteracy Competency Domains

The domain of ecoliteracy competence includes the key domains of knowledge, critical thinking, awareness, practical skills, and participation derived from the literature review.

Ecological knowledge

Ecological knowledge relates to ecosystems, interactions between living organisms, and their relationship with the environment. Knowledge of ecosystems is a key foundation in ecoliteracy, which emphasizes the importance of relationships and dependencies between natural components such as plants, animals, water, and soil (Abdullah, 2023; Ardoin et al., 2015; Arif et al., 2025; Flowers et al., 2015). In a balanced ecosystem, each element plays a role in maintaining the system's sustainability. For example, plants produce oxygen and food for herbivores, while animals help disperse seeds and enrich the soil through decomposition. Water and soil support plant and animal life, creating natural cycles that support life (Ardoin et al., 2015; Ma et al., 2023). Awareness of these interactions is important for humans to appreciate and strive to maintain the balance of nature (Carbonell-Alcocer et al., 2023; Kiewra et al., 2023).

On the other hand, human activities such as urbanization, intensive agriculture, and industry significantly impact ecosystems (Ardoin et al., 2020; van de Wetering et al., 2022). Urbanization causes deforestation and reduces natural habitats for wildlife, while industry often produces waste that pollutes air, water, and soil (Ardoin et al., 2020). Intensive agriculture also leads to soil degradation and excessive water consumption, ultimately disrupting the balance of ecosystems (van de Wetering et al., 2022). Knowledge of the impacts of these activities is important so that people are wiser in managing resources and minimizing environmental damage (Svobodová & Kroufek, 2022; West, 2015).

Green technology is a necessary solution to reduce negative impacts on the environment. Technologies such as renewable energy, waste management, and sustainable agricultural systems can help support ecosystem sustainability (Ardoin et al., 2022; Powell et al., 2023) for example, the use of solar panels or wind turbines can reduce dependence on fossil fuels that pollute the environment. Good waste management systems can reduce water and soil pollution, while organic farming methods help maintain soil quality without pesticides (Powell et al., 2023). An understanding of these technologies allows communities to make choices that are more supportive of sustainability. In addition, local and place-specific knowledge also plays an important role in ecoliteracy. Each ecosystem has unique flora, fauna, and soil and water characteristics (Szczytko et al., 2018). Understanding local environmental conditions helps individuals be more connected to and responsible for preserving nature around them. For example, recognizing endangered plant and animal species in a particular area can encourage more focused conservation efforts. This local knowledge enriches insights and encourages concrete actions in maintaining regional biodiversity and ecosystem stability (Szczytko et al., 2018). The stages of ecological knowledge are visualized by the author based on the results of thematic synthesis of the analyzed article in **Figure 2**.

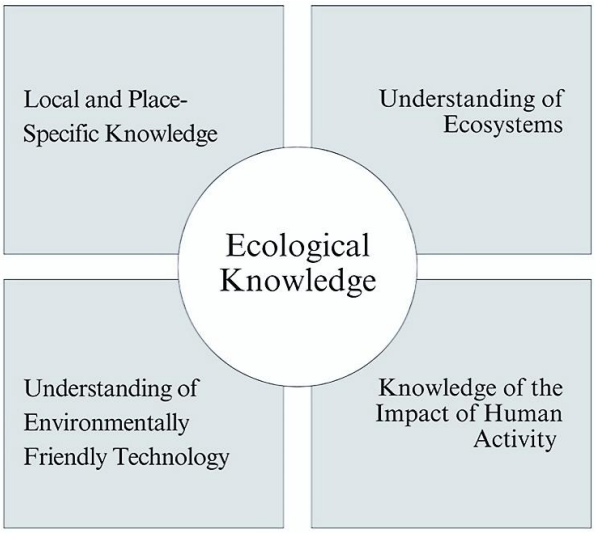

Figure 2. Dimensions of ecological knowledge (Source: Authors' own elaboration)

Critical thinking skills

Critical thinking in ecoliteracy is the ability to deeply analyze environmental issues with an objective and evidence-based approach and make wise decisions in the face of ecological challenges (van de Wetering et al., 2022). Critical thinking begins with identifying an environmental problem or question to be solved, such as the impact of climate change or plastic pollution on ecosystems. This step helps clarify the focus and purpose of the research or solution to be developed. Once the main issue is determined, the next step is to gather relevant information from various reliable sources, such as scientific research, environmental reports, or field observations. Accurate and valid data is essential to provide a solid foundation for understanding the ecological issue. The next stage is to analyze and

Figure 3. Stages of critical thinking skills (Source: Authors' own elaboration)

evaluate the ecological data that has been collected. The data is examined at this stage to understand cause-and-effect relationships and identify patterns or trends affecting the ecosystem. In addition, it is important to verify the reliability of the information sources to make the analysis reliable. After analyzing the data, the next step is to develop rational and well-founded conclusions or solutions to effectively address the environmental issue (Ardoin et al., 2022; Firinci Orman, 2024; Pearce, 2024).

Another step is to evaluate alternative solutions and their environmental impact. We can choose the most sustainable and ecosystem-benefiting solution by considering each action's various options and consequences. This process ends with reflection and revision, reviewing the conclusions or solutions to ensure their relevance and effectiveness. If new information or additional perspectives emerge, solutions can be adjusted to address ecological challenges more comprehensively and adaptively (Hasslöf et al., 2016; Reffhaug & Lysgaard, 2024). Critical thinking stages visualized by the author based on the results of thematic synthesis of the analyzed article in **Figure 3**.

Environmental awareness

Ecological awareness is a deep understanding of the relationship between humans and the environment, as well as recognition of an individual's responsibility in maintaining ecosystem balance (Ballard et al., 2024; Gazoulis et al., 2022; Sprague et al., 2022). This awareness involves recognizing the impact of every human action on nature and motivation to behave more environmentally friendly. The stages of environmental awareness start from initial awareness, where individuals begin to realize ecological issues such as climate change, pollution, or species extinction (Ardoin et al., 2015). This awareness is usually gained from various sources, such as media, education, or personal observation, and is the first step to recognizing that environmental issues need attention. Once awareness is established, individuals move to the in-depth understanding stage of seeking more information and learning about the causes and impacts of existing environmental problems. At this stage, individuals develop a deeper understanding of ecological concepts, including life cycles, ecosystem interactions, and how human activities can affect the environment. The next stage is concern, where individuals begin to feel emotionally moved to care about the impacts of the environmental issues they understand. A sense of responsibility arises, and a desire to reduce negative environmental effects, especially concerning threatened species, habitat destruction, and other nature destruction issues. This concern then develops into the desire to act, which is the drive to do something tangible to protect or improve the environment. At this stage, individuals feel that personal actions can have a positive impact, and there is motivation to make changes (Clark et al., 2020; Galli et al., 2020; Lin et al., 2022; Tiwari, 2023; Wierzbiński et al., 2021).

The final stage in the environmental awareness process is action, which involves concrete steps to support environmental conservation. Individuals begin to implement changes in their daily behavior, such as reducing plastic use, recycling, using more environmentally friendly transportation, or even participating in conservation activities. Through this stage, environmental awareness transforms from understanding to concrete actions that positively impact the preservation of nature. These stages show that ecological awareness does not just stop at understanding but develops into real, sustainable behavior. Each stage strengthens an individual's commitment to maintaining ecosystem balance and supporting environmental sustainability (Botella et al., 2022; Carbonell-Alcocer et al., 2023; Ma et al., 2023; Wu et al., 2020). The stages of environmental awareness are visualized by the author based on the results of thematic synthesis of the analyzed article in **Figure 4**.

Practical skills

The stages of practice in ecoliteracy involve a gradual process to increase understanding and sustainable action towards the environment. The general stages in ecoliteracy are the first stage of awareness and observation, which begins with an introduction to the surrounding environment, including flora, fauna, and other ecosystem elements. Individuals are invited to observe the environment, understand the role of each component, and recognize existing environmental issues, such as pollution, deforestation, or drought

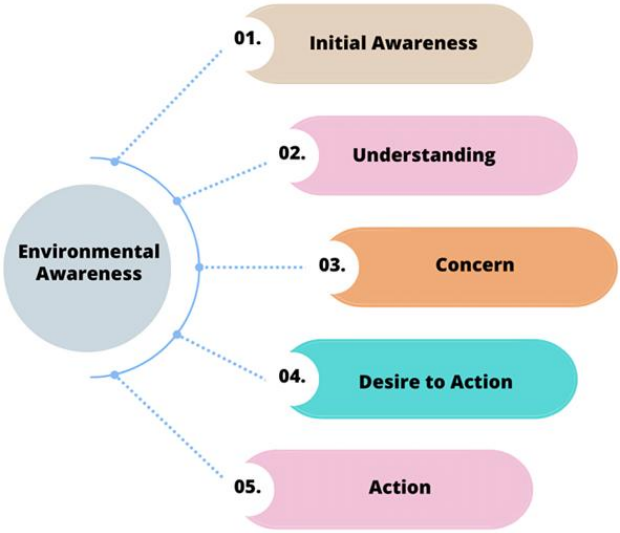

Figure 4. Environmental awareness component (Source: Authors' own elaboration)

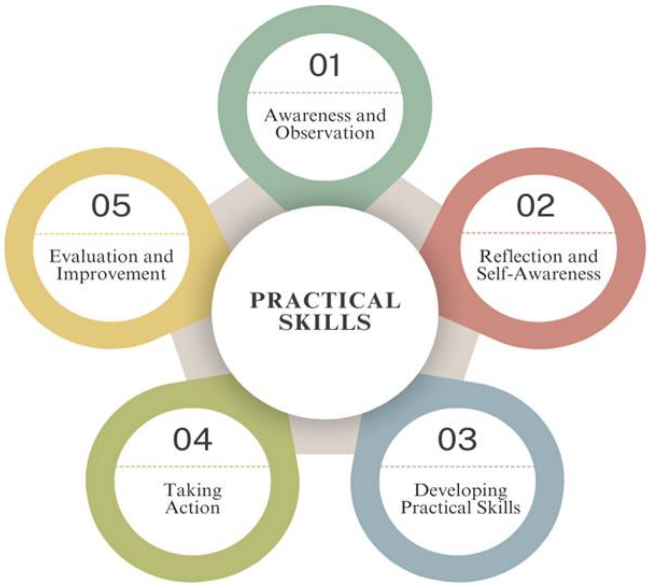

Figure 5. Practical skills component (Source: Authors' own elaboration)

(Ardoin et al., 2023). The second stage is reflection and self-awareness, in which individuals reflect on how their daily activities affect the environment. This stage involves self-awareness of environmentally unfriendly behaviors and understanding human activities' negative impacts. This reflection is important to generate personal responsibility for nature conservation.

Furthermore, the third stage is developing practical skills. In this stage, individuals learn skills that support environmentally friendly behavior, such as recycling, saving energy, organic gardening, or composting. This stage helps individuals apply ecological concepts to daily practices, thus having a positive impact on the environment. Fourth is taking action. After developing practical skills, individuals implement concrete actions to preserve the environment. This could be a lifestyle change, such as reducing plastic use, switching to more environmentally friendly transportation, or participating in local conservation activities (Dale et al., 2020; Datu & Buenconsejo, 2021; Galli et al., 2020; Lin et al., 2022; O'Hare et al., 2020).

Stage five is evaluation and improvement, and the final stage involves evaluating the actions' impact. Individuals reflect on the effectiveness of the practices that have been carried out and look for ways to continue to improve environmentally friendly behavior. This stage allows individuals to continue to innovate in environmental conservation efforts and inspire others. These stages of practice in ecoliteracy encourage sustainable behavior change, from introduction to concrete action and ongoing evaluation. This process aims to foster awareness and active involvement in maintaining ecosystems and supporting environmental sustainability (Dale et al., 2020; Datu & Buenconsejo, 2021; Galli et al., 2020; Lin et al., 2022; O'Hare et al., 2020). Based on the explanation of the stages of practical skills, the author can visualize these stages based on the results of the thematic synthesis of the analyzed article in **Figure 5**.

Active participation

The stages of active participation in ecoliteracy involve steps that encourage individuals to play a direct role in protecting and preserving the environment. The first stage of active participation is engagement in local actions. At this stage, individuals begin to participate in environmental activities in the local community, such as river cleaning, reforestation, or recycling programs. Through this engagement, individuals gain first-hand experience and begin to see the impact of environmental action on the local ecosystem. Second, advocacy and information sharing, with increased experience and understanding, individuals start to engage in ecological advocacy by spreading information and raising awareness in the community. Individuals can share their knowledge through social media, organize environmental campaigns, or provide education in schools and communities. This advocacy aims to involve more people in environmental conservation (Gatan et al., 2021; Goulgouti et al., 2019; Kiewra et al., 2023).

Third is collaboration with communities or organizations; at this stage, individuals work with groups or organizations with the same mission, such as environmental NGOs or local communities. This collaboration strengthens conservation efforts and allows individuals to participate in larger projects or programs, such as forest rehabilitation or species conservation. The final stage is to become a leader in environmental action, where individuals participate and initiate and lead ecological projects. At this stage, individuals are responsible for directing and inspiring others to protect the environment and create sustainable

Figure 6. Active participation component (Source: Authors' own elaboration)

solutions that have a wider impact. These stages of active participation help individuals progress from simply understanding environmental issues to becoming active leaders in conservation efforts. Each stage strengthens commitment to nature conservation and encourages others to take part in environmental sustainability (Ardoin et al., 2020; Botella et al., 2022; Carbonell-Alcocer et al., 2023; Ma et al., 2023; Powell et al., 2023; Wu et al., 2020). Based on the explanation of the stages of active participation, the author can visualize these stages based on the results of the thematic synthesis of the analyzed article in **Figure 6**.

The researcher provides a visualization of the realm of ecoliteracy in the form of a tiered pyramid to illustrate the stages of development of ecoliteracy competence. Knowledge is the foundation at the base, which provides a basic understanding of environmental concepts. Next, it is critical to emphasize critical thinking skills for analyzing ecological issues in depth. The next stage, awareness, includes awareness of environmental impacts and the urgency of sustainability, which develops from knowledge and critical analysis. The fourth level, practical, demonstrates applying ecological knowledge and understanding to concrete actions, allowing individuals to contribute to sustainable practices. At the top of the pyramid is participation, where individuals are actively involved in environmental activities as a form of full commitment to sustainability. This model shows that ecoliteracy development starts from fundamental knowledge to active engagement, with skills and awareness as an important bridge to reach practical application and active participation. This visualization shows the progression from knowledge foundation to active engagement, reflecting that ecoliteracy is about understanding and involvement in environmental conservation efforts. Based on the explanation of the ecoliteracy competency domains, the author can

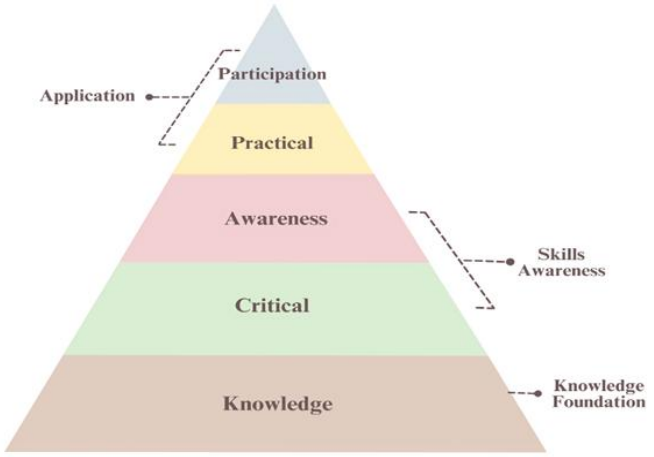

Figure 7. Tiered pyramid of ecoliteracy domains (Source: Authors' own elaboration)

visualize these stages based on the results of thematic synthesis of the analyzed article in **Figure 7**.

Educational Approaches to Developing Ecoliteracy

The development of ecoliteracy involves various approaches and strategies. It aims to form a generation that understands the importance of protecting the environment and can play an active role in real environmental conservation actions. Approaches that can be applied in education to develop ecoliteracy in learning.

Experiential learning approach

Experiential learning encourages learners to learn directly from real experiences. Experiential learning focuses on learning through direct engagement in relevant activities, such as field projects, experiments, and role plays, designed to foster critical thinking skills and reflection (Pearce, 2024). This method emphasizes the importance of reflection after hands-on experiences to strengthen understanding and connection with the learning material (Ardoin et al., 2018; Hui et al., 2023; Kūlnieks, 2023). This approach directly emphasizes student interaction with natural elements and communities, facilitating deep ecological awareness and encouraging active engagement in environmental issues (Firinci Orman, 2024; Pearce, 2024).

Collaboration with local communities

Collaboration with local communities is an approach that engages communities in participatory environmental projects to improve ecoliteracy and sustainability (Ballard et al., 2024; Lin et al., 2022; Tiwari, 2023). Through involvement in data collection and environmental monitoring, communities increase ecological knowledge and feel ownership of the project (Clark et al., 2020; Gazoulis et al., 2022). Local knowledge combined with modern scientific data results in effective contextualized solutions, while this engagement

strengthens social bonds and a collective sense of responsibility toward environmental conservation (Ballard et al., 2024; Galli et al., 2020). Moreover, these collaborations empower communities with new skills and roles in decision-making, resulting in long-term impacts in the form of pro-environmental behaviors that are sustained and passed on to the next generation (Galli et al., 2020; Wierzbiński et al., 2021).

Project-based education approach

Project-based education is a learning approach that prioritizes the active participation of participants in real projects related to environmental issues. This approach aims to create an immersive learning experience by integrating theory and practice, allowing learners to understand the complexity of the environment while applying it in a real-world context (Ardoin et al., 2023; Carbonell-Alcocer et al., 2023; Powell et al., 2023). The PBE approach encourages students to identify environmental problems, design creative solutions, and implement them through collaborative projects that often involve local communities or relevant stakeholders (Botella et al., 2022; Ma et al., 2023; Powell et al., 2023; Wu et al., 2020).

Integrated curriculum approach

The integrated curriculum approach is a method that combines various disciplines to form a holistic and interdisciplinary understanding of ecoliteracy and sustainability. This approach aims to connect concepts from different subjects, such as science, geography, and social studies, focusing on environmental issues. In this way, students can see the linkages between scientific knowledge, social impacts, and ecological implications, allowing them to develop a more thorough understanding of ecosystems and sustainability (Ardoin et al., 2015; Datu & Buenconsejo, 2021; LeSage-Clements et al., 2024; van de Wetering et al., 2022).

Targeted campaigns and information approach

Targeted campaigns and information is an approach that uses customized campaigns and information dissemination to increase students' environmental awareness. These campaigns can be in posters, seminars, or social media tailored to specific environmental topics, such as recycling or reducing plastic use. Information presented in an engaging and relevant way to students can increase their knowledge and encourage behavior change. These targeted campaigns effectively provide environmental education in a short time but greatly impact learners' understanding and attitude towards environmental issues (Gan et al., 2021; Głbiński, 2015).

Digital technology approach

Digital technology is an approach in ecoliteracy education that uses digital tools to enhance students' understanding of environmental issues. Technologies such as ecosystem simulation apps, online learning, and the use of social media allow students to learn about ecosystems, ecological impacts, and sustainable solutions interactively and engagingly. These technologies can also facilitate broader learning, strengthen digital skills, and allow students to connect with global environmental communities or projects (Abdullah, 2023; Ricoy & Sánchez-Martínez, 2022).

Impact of the Approaches in Ecoliteracy Education

The approaches in ecoliteracy education greatly impact the development of students' understanding and awareness of the environment. The impacts of approaches that can be applied in education to develop ecoliteracy in learning are Experiential Learning significantly enhance ecoliteracy through the enrichment of ecological knowledge, emotional attachment, and pro-environmental behavior (Kūlnieks, 2023; Reamer, 2023). The approach supports deep cognitive understanding by providing hands-on experiences that connect students to local and global ecosystems (Czajkowska & Ingaldi, 2023; Kiewra et al., 2023). The affective dimensions encourage motivation to act and strengthen ecological awareness through active engagement in environmental action (Lovren & Jablanovic, 2023; Pearce, 2024). Innovations such as eco-pedagogy and immersive technologies are also instrumental in creating holistic learning that inspires environmentally conscious behavior and collective participation (Firinci Orman, 2024; Hui et al., 2023). These approaches emphasize the importance of interactions between humans and nature and facilitate an understanding of long-term sustainability in education (Pearce, 2024; Reamer, 2023).

The project-based education approach helps participants understand the interactions between ecosystem components and human impacts on the environment, thereby fostering awareness of the importance of maintaining ecosystem sustainability and balance (Ardoin et al., 2020; Carbonell-Alcocer et al., 2023; Powell et al., 2023). In addition, participants acquire practical skills such as resource management and environmental restoration techniques. Projects that involve making their own materials or restoration activities, such as tree planting, reinforce these skills (Botella et al., 2022; Ma et al., 2023). Project-based education also promotes sustainable behavioral changes, such as recycling practices, waste reduction, and more efficient use of resources, where hands-on experience in projects motivates participants to adopt environmentally friendly habits (Carbonell-Alcocer et al., 2023; Wu et al., 2020).

The integrated curriculum approach shows improvements in several key ecoliteracy domains, namely the development of a deeper understanding of ecosystems and sustainability principles by linking

different disciplines, allowing learners to see the connections between concepts as a whole (Datu & Buenconsejo, 2021; van de Wetering et al., 2022). Integrating subjects focusing on environmental issues promotes the critical thinking and analysis skills needed to understand complex environmental challenges and seek innovative solutions (van de Wetering et al., 2022). By embedding sustainability concepts into various subjects, this approach also increases students' pro-environmental awareness and attitudes, making learners more responsive and aware of the environmental impact of actions (Datu & Buenconsejo, 2021). An integrated curriculum that involves students in collaborative projects or activities fosters active engagement in pro-environmental activities, such as restoration projects or scientific research focused on local issues (Datu & Buenconsejo, 2021; van de Wetering et al., 2022).

Targeted campaigns and information can improve ecoliteracy, especially regarding environmental awareness and knowledge. Increased awareness helps encourage public participation in pro-environmental activities, while environmental knowledge supports better, fact-based decision-making (Cutter-Mackenzie & Smith, 2003). Deep learning also moderates the influence of awareness, making decisions more objective and informed (Albuquerque et al., 2021). Thus, targeted and informative campaigns can strengthen ecoliteracy and encourage more environmentally conscious actions (Güven & Uyulgan, 2021).

Digital technology approaches are important in improving ecological literacy and environmental awareness. Social media platforms, such as Twitter, disseminate information, build awareness, and facilitate education on environmental issues (Ricoy & Sánchez-Martínez, 2022). Digital tools such as keyword analysis and analytics software help understand research trends, key themes in ecological literacy, and the effectiveness of digital communication (Ricoy & Sánchez-Martínez, 2022). In addition, digital technologies in education can involve the application of interactive tools and analytics to monitor audience impact and engagement, thus supporting the development of ecoliteracy through a more engaging and participatory approach (Abdullah, 2023).

Education Implications Regarding This Study

The main implication of this research is the importance of a holistic approach in ecoliteracy education that covers various domains, such as basic ecological knowledge, critical thinking skills, environmental awareness, practical application, and active participation. Effective approaches in building ecoliteracy competencies include experiential learning, and project-based learning, which direct learners to learn directly from their surrounding environment. These approaches are supported by curriculum integration and community collaboration, which enrich students' learning experiences. The impact of these approaches is significant, especially in improving students' environmental knowledge, critical awareness and practical skills. Students not only understand ecological issues but are also encouraged to actively participate in conservation actions. These positive impacts show that ecoliteracy education with the right approach can produce individuals who care and are responsible for environmental sustainability.

Research Limitations

This study has several limitations that need to be considered. First, the scope of the literature sources used is limited. As a SLR, this study relies on articles and journals available in specific databases, so there may be relevant approaches or outcomes in ecoliteracy education that are missed because they are not included in those databases. The second limitation is the variability in the definition and application of ecoliteracy across studies. This research incorporates various approaches and impacts in ecoliteracy education, but the meaning and scope of ecoliteracy may vary among the analyzed studies. These differences require comprehensive analysis in drawing uniform conclusions about the components of ecoliteracy, as different studies may have different focuses or interpretations of the concept.

CONCLUSION

Based on the main findings, ecoliteracy competencies in education can be divided into several domains that complement each other. These domains include basic knowledge of ecology (knowledge), ability to think critically about environmental issues (critical thinking), awareness of environmental impacts (awareness), ability to apply knowledge practically (practical application), and active participation in ecological activities (participation). Effective approaches to building ecoliteracy include experiential learning and project-based education, allowing students to learn directly from their surrounding environment. These approaches are supported by curriculum integration and community collaboration, which enrich students' learning experiences. These strategies foster deep understanding and encourage direct student engagement in sustainability issues. The impact of these approaches on learners is significant, especially in improving environmental knowledge, critical awareness, and practical skills. Students understand ecological issues and are encouraged to participate actively in conservation actions. These positive effects show that ecoliteracy education with the right approach can produce individuals who care and are responsible for environmental sustainability.

Future research is recommended to explore other approaches to ecoliteracy that have not been widely researched. Approaches such as more in-depth use of digital technology or integrative methods involving various disciplines in the curriculum could be interesting topics for further exploration. These approaches have the potential to provide new perspectives and can enrich ecoliteracy learning strategies in different educational contexts. In addition, empirical research is needed to assess the long-term effects of ecoliteracy education on learners' environmental behavior. Such studies will help us understand whether the impact of ecoliteracy received in formal or informal education contributes to sustainable behavior change. This long-term research can provide insights into the effectiveness of ecoliteracy programs in shaping a more environmentally responsible generation.

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Declaration of interest: No conflict of interest is declared by the authors.

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