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Fostering Environmental Literacy and Creativity in Biology Education: A Systematic Review of Place-Based Learning in Conservation Areas

M Ikhsan Al Ghazi
Universitas Negeri Yogyakarta, Yogyakarta

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Abstract

Biology education currently faces a significant challenge in transforming cognitive biodiversity knowledge into added value for national development. The inability of pre-service teachers to integrate scientific data with creative solutions has resulted in low levels of applicable environmental literacy. This study aims to identify the potential and strategies for fostering environmental literacy and creativity among students through a systematic review of place-based learning in conservation areas. The method employed is a Systematic Literature Review (SLR), analyzing reputable scientific articles and utilizing bibliometric visualization through VOSviewer software to map research gaps. The results indicate a clear dichotomy between the mastery of ecological theory and students' creative capacity. Network analysis reveals that environmental literacy has been dominated by conventional waste management issues and remains isolated from creative problem-solving aspects and conservation area contexts. The conclusion of this study emphasizes that conservation areas, such as ecotourism sites, play a crucial role as living laboratories to bridge this gap. These findings serve as an empirical foundation for developing more structured project-based experiential learning models. In-depth identification of students' environmental literacy and creativity in the field is required as an initial step to prepare future educators capable of engineering solutions to local biological crises while contributing to the national creative industry

Corresponding Author:
M Ikhsan Al Ghazi
Universitas Negeri Yogyakarta, Yogyakarta
Email: alghazi@uny.ac.id

1. INTRODUCTION

Biology Education, in the 21st century It is no longer just about the transfer of knowledge about living systems, but about the formation of agents of change that are able to answer the global biodiversity crisis. In the midst of the threat of massive environmental degradation, students who are prospective biology teachers holding a strategic role as the front line in fostering ecological awareness for future generations. However, environmental literacy (Nurhasanah, 2020; Solomon et al., 2011)(Rinekso, 2021; Turiman et al., 2019)(https://www.cbd.int/countries/profile, n.d.; Imamah & Gumaran, 2021)(Roll & Ifenthaler, 2021),(Setiawan et al., 2022), It is often only understood narrowly as the mastery of ecological knowledge, without being accompanied by the ability to engineer solutions born from creativity. As a result, there is an educational paradox: students master the theory of biodiversity cognitively, but fail to transform it into added value for national development and real nature conservation.(Lee, 2022; Mia Hocenski, Ljerka Sedlan König, 2018)

This competency gap is rooted in learning models that tend to be isolated from the reality of the field. Referring to the National Development Strategic Priorities, the downstream of national research and industrialization is currently held back by the low

capacity of human resources in carrying out biological resource-based engineering. In higher education, collaboration between academics and the field sector, such as conservation areas and ecotourism, is still sporadic. In fact, conservation areas offer "living laboratories" that are able to provide concrete experiences for students. Without active involvement in a real environmental context, students' creativity in solving conservation problems becomes dull, and their environmental literacy remains at a passive theoretical level.(Ronquillo et al., 2020; Syahabuddin et al., 2020)

Yogyakarta, as an educational center with a wealth of community-based ecotourism potential like in Jatimulyo, should be the basis for developing innovative learning models. However, this potential has not been optimally utilized in the biology education curriculum. Prospective students need a learning space that not only requires them to memorize taxonomy, but also trains them to become "project managers" capable of managing scientific data into creative products of economic and conservative value. Therefore, a (Hasanah, 2022; Hasanah & Supardi, 2020; Santoso et al., 2016)*Place-Based Learning approach* is needed that is able to integrate environmental literacy and creativity in a single competency unit.(HoşgšrŸr, 2012)

This study aims to conduct a systematic review of the effectiveness of place-based learning in conservation areas as a strategy to foster environmental literacy and student creativity. Through an in-depth identification of the global and local literature, this study is expected to reveal how direct interaction with conservation ecosystems can trigger creative problem-solving skills. The results of this review will be a crucial empirical foundation in designing future learning models that are able to reduce the gap in the capacity of research and engineering human resources in Indonesia.

2. RESEARCH METHODS

This study uses a qualitative research type with a Systematic Literature Review approach (Suhartono, 2017). The main focus of the research is to synthesize various literature on environmental literacy and creativity in the context of learning in conservation areas. The research data is in the form of secondary data sourced from articles of reputable scientific journals indexed by the Scopus database in the last ten years (2016–2025).

Data collection techniques are carried out through identification, screening, and eligibility procedures. Literature search using a combination of keywords: "Environmental Literacy", "Biology Pre-service Teachers". The inclusion criteria set are: (1) the article is the result of empirical research; (2) focus on prospective biology teacher students; and (3) located or using the context of a conservation/ecotourism area. The results of the search in Scopus found 232 documents.

The data analysis technique uses Content Analysis which is carried out using the help of the vosviewer application. The analysis process includes data reduction from the main findings of the selected articles, presentation of data in the form of a synthesis table, and drawing conclusions related to the pattern of relationship between the environmental context and the improvement of student competence. This analysis is aimed at mapping the gaps of previous research as a basis (needs analysis) for the development of new learning models.

3. RESULTS AND DISCUSSION

This section presents the results of digital literature mapping and bibliometric analysis to answer research questions regarding environmental literacy trends and creativity in biology education. Data visualization is obtained through metadata processing from the Scopus database using the VOSviewer software. This mapping aims to see the connections between concepts (nodes) and identify research gaps that have not been touched in the last ten years. The network that is formed is based on the link strength between keywords that

appear simultaneously (co-occurrence), which are then grouped into thematic clusters based on the proximity of the topic, as seen

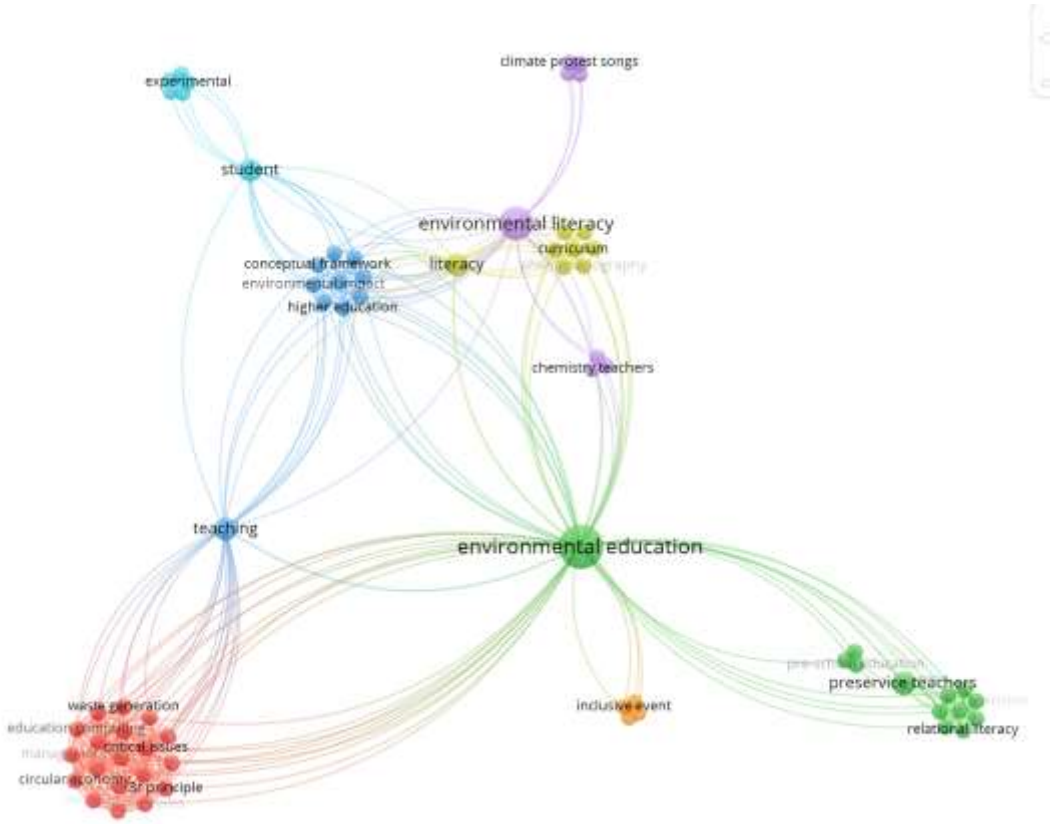

Figure 1. Environmental literacy theme concept map

1. Bibliometric Characteristics and Topic Clustering

Based on a network analysis of literature published between 2016-2026 (Figure 1), four main clusters were found that represent the direction of environmental literacy research in current prospective teachers:

1. **Technical Dominance Cluster (Red):** This cluster includes keywords such as *waste generation, circular economy,* and *3R principle*. This shows that the main focus of environmental literacy in biology education is still "downstream" or oriented towards waste management, not on upstream innovation.
2. **Pedagogy and Curriculum Cluster (Purple & Yellow):** Focus on *environmental literacy, curriculum,* and *literacy*. The data show that environmental literacy is more studied as part of the development of a formal curriculum than as an adaptive practical competence.
3. **Subject and Institutional Cluster (Blue):** Connecting *higher education* and *preservice teachers*. This confirms that the subjects of prospective biology teachers are the most frequently researched group, but are often still limited to the campus academic environment (*indoor-based*).
4. **Environmental Education Cluster (Green):** This is the largest cluster centered on *environmental education*. Although it is robust in frequency, this cluster has a wide range of creativity variables.

3.2. Identifying Gaps: Environmental Literacy vs Creativity

The results of the visual analysis show that **there is no strong connection** between the environmental *literacy nodes* and *creativity* or *creative problem-solving*. A detailed explanation of this finding is as follows:

- **Absence of Creativity Variables:** The very small size of the creativity node (or even not significantly absent in the main network) proves that the development of divergent thinking skills in solving ecological problems has not been a priority in biology education research over the past decade.
- **Disconnection with Conservation Context:** Network analysis shows that the term *conservation area* or *ecotourism* has not yet emerged as an integrated keyword. This confirms that students' environmental literacy is still theoretical-cognitive and has not been explored in the context of natural laboratories or conservation areas.

3.3. The Urgency of Integrating Place-Based Learning in Conservation Areas

Based on the data above, there is an urgent need to formulate a learning model that is able to connect green clusters (*environmental education*) with solution engineering aspects (creativity). *Place-based learning* in conservation areas such as Jatimulyo is offered as a bridge to:

1. **Shifting the Paradigm:** From simply understanding the waste problem (red clusters) to being able to create innovative products based on biodiversity (creativity).
2. **Contextualization of Competencies:** Bringing prospective teacher students out of institutional boundaries (blue clusters) to real experiences in the field (*experimental*) to foster a deeper environmental sensitivity.

DISCUSSION

4.1. Misconnection between Environmental Literacy and Creative Capacity

The results of the network analysis show that there is a clear dichotomy between mastering environmental literacy and developing creativity in prospective biology teacher students. Although environmental literacy is a central topic (green and purple clusters), its connection to creative capacity is still very weak. This confirms that biology education is currently still dominated by a cognitivism approach that emphasizes the accumulation of ecological knowledge, but does not provide space for students to engineer solutions to biological crises. Without the integration of creativity, students' environmental literacy will only stop at the awareness stage(Ghazi et al., 2022; Sudrajat et al., 2025) without transforming into innovative *responsible behavior*.(Hasanah et al., 2024)

4.2. Conservation Areas as a "Missing Link" in Learning

The wide distance between the higher education cluster (blue) and the environmental technical issues cluster (red) reflects the disconnect between the academic world and the reality of the field. The lack of the appearance of keywords related to "conservation area" or "ecotourism" in the literature map shows that the potential of natural laboratories has not been systematically optimized. Conservation areas, such as Jatimulyo Ecotourism in Yogyakarta, actually have a crucial function as a real context that can trigger *experiential learning (Wardhana et al., 2024)*. At the location, students are not only studying biodiversity staticly, but are faced with real problems that demand flexibility and originality of thinking—two key indicators of creativity according to Torrancem to align between the economic needs of communities and ecosystem sustainability.(Wulandari et al., 2024)

4.3. Towards a Downstream Project-Based Learning Model

The research gap found through bibliometric data reinforces the urgency of developing new and more holistic learning models. Students' environmental literacy needs to be improved from just understanding conventional waste management (3R)

to creative project management skills. The integration of project-based (Cenoz & Gorter, 2011; Fitriyah et al., 2022)*Experiential Learning* models with the context of ecotourism is a strategic solution to bridge scientific data with the needs of the creative industry. Through this approach, prospective teacher students are trained to *scale-up* from biological concepts to products or services that have national added value, in line with the strategic priorities of downstream research in higher education.

4.4. Implications for Human Resources Development of Prospective Teachers

These findings provide a strong basis for a preliminary study in Yogyakarta to map the specific needs of students. As aspiring educators, biology students must have "dual literacy": literacy of environmental science and literacy of creative innovation. If this capacity gap is not immediately addressed through structured learning model interventions, then the vision of national development to create superior research human resources will be difficult to achieve. Therefore, identifying environmental literacy and student creativity in the field is a crucial step before engineering a learning model that is truly based on real needs.(Indra & Novika, 2022)

4. CONCLUSION

Based on the results of systematic analysis and bibliometric mapping, it can be concluded that there is a significant gap between the cognitive mastery of environmental literacy and the development of the creativity of prospective biology teacher students. Research over the past decade has been dominated by conventional and administrative environmental management issues, but it still very rarely touches on the engineering aspects of innovative solutions. In addition, the potential of conservation areas as natural laboratories has not been firmly integrated in the biology education research network, so learning tends to be theoretical and isolated from real challenges in the field.

These findings provide a strong foundation for the urgency of developing more contextual learning models. A learning model, such as project-based *Experiential Learning* in the context of ecotourism, is needed that is able to bridge the understanding of biodiversity with students' creative skills. The first step through the identification of environmental literacy and student creativity in Yogyakarta is very crucial as a baseline for designing effective educational interventions. Thus, future biology teacher candidates will not only play the role of teachers, but also innovators who are able to provide economic and ecological added value for sustainable national development.

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