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REVIEW

Cultural Literacy in Biology Education: Theoretical Foundations and Future Directions

Alfabetización cultural en la educación biológica: fundamentos teóricos y direcciones futuras

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ABSTRACT

Introduction: cultural literacy is recognized as a crucial component in biology education because it allows the integration of scientific concepts with local cultural values, narratives, and practices. The objectives of this study are 1) to identify the main elements that constitute the focus of cultural literacy research in biology education, 2) to analyze the theories and conceptual approaches employed in the study of cultural literacy within biology education, and 3) to outline the future directions and potential research opportunities related to cultural literacy in the context of biology education.
Method: this study employed a Systematic Literature Review (SLR) following PRISMA guidelines. A total of 12 articles were analyzed after completing the screening and eligibility process using the PRISMA framework.
Results: findings reveal four main elements in cultural literacy research: integration of local values, development of culture-based curricula, strengthening cultural identity, and fostering multicultural competencies. Theoretical approaches include Culturally Responsive Teaching, Social Constructivism, and Ethnopedagogy. Research gaps include the absence of standardized measurement instruments, underdeveloped culture-based learning technologies, and limited empirical studies linking cultural literacy to ecological attitudes.
Conclusions: cultural literacy enriches biology education by bridging science with socio-cultural realities, contributing to sustainable development goals. Addressing conceptual and methodological gaps through cross-disciplinary approaches and community engagement will enhance relevance, equity, and sustainability in biology learning.

Keywords: Cultural Literacy; Biology Education; Local Wisdom.

RESUMEN

Introducción: la alfabetización cultural se reconoce como un componente crucial en la educación biológica porque permite la integración de conceptos científicos con valores, narrativas y prácticas culturales locales. Los objetivos de este estudio son 1) identificar los principales elementos que constituyen el enfoque de la investigación de la alfabetización cultural en la educación biológica, 2) analizar las teorías y los enfoques conceptuales empleados en el estudio de la alfabetización cultural dentro de la educación biológica, y 3) delinear las direcciones futuras y las oportunidades potenciales de investigación relacionadas con la alfabetización cultural en el contexto de la educación biológica.
Método: este estudio empleó una revisión sistemática de la literatura (SLR) siguiendo las pautas de PRISMA. Se analizaron un total de 12 artículos después de completar el proceso de selección y elegibilidad utilizando el marco PRISMA.

Resultados: los hallazgos revelan seis elementos principales en la investigación de la alfabetización cultural: integración de valores locales, desarrollo de planes de estudio basados en la cultura, fortalecimiento de la identidad cultural y fomento de competencias multiculturales. Los enfoques teóricos incluyen la enseñanza culturalmente receptiva, el constructivismo social y la etnopedagogía. Las brechas de investigación incluyen la ausencia de instrumentos de medición estandarizados, tecnologías de aprendizaje basadas en la cultura subdesarrolladas y estudios empíricos limitados que vinculan la alfabetización cultural con las actitudes ecológicas.
Conclusiones: la alfabetización cultural enriquece la educación biológica al unir la ciencia con las realidades socioculturales, contribuyendo a los objetivos de desarrollo sostenible. Abordar las brechas conceptuales y metodológicas a través de enfoques interdisciplinarios y la participación de la comunidad mejorará la relevancia, la equidad y la sostenibilidad en el aprendizaje de la biología.

Palabras clave: Alfabetización Cultural; Educación Biológica; Sabiduría Local.

INTRODUCTION

Cultural literacy is basically the ability of individuals to recognize, understand, appreciate, and reflect on cultural values, practices, and symbols in social life and learning.[1,2] This concept develops from the idea that education should not be culturally neutral, but rather responsive to the diversity of students' identities, experiences, and cultural heritage.[3] Several studies show that the level of cultural literacy of students is currently still relatively low. Many students do not have an adequate understanding of the local cultural values around them, and even experience alienation from cultural practices that are passed down from generation to generation.[4] This condition is exacerbated by the currents of globalization and digitalization that shift the attention of the younger generation from traditional knowledge to instant information that is not always relevant to the local context.[5] Low cultural literacy has an impact on the lack of appreciation for local wisdom related to conservation, health, and sustainability.[6]

Various previous studies have examined literacy in the context of education, especially science literacy,[7] environmental Literacy,[8] digital literacy, and multiliteracy.[9] Several studies generally emphasize the importance of critical thinking skills, conceptual understanding, and the ability to make decisions based on accurate scientific information. Science and environmental literacy is a major focus, particularly in topics such as climate change, ecosystem cycles, and the impact of human activities on nature.[10,11] However, the cultural dimension of literacy is still often treated as an additional aspect, rather than an integral part of the biology learning process itself. Most of the research that raises cultural aspects only focuses on the exploration of local wisdom or the development of culture-based media, without linking it to the theoretical and systematic framework of cultural literacy.[12,13,14] Gaps in academic literature that need to be bridged through studies that not only describe practice, but also develop conceptual foundations, as well as directions for the development of relevant cultural literacy in biology education.

This study is designed to achieve three primary objectives. First, it seeks to identify the main elements that form the focus of cultural literacy research in biology education. Second, it aims to examine the theories and conceptual approaches that have been applied in previous studies of cultural literacy within this educational context. Third, it intends to outline future directions and potential research opportunities that may contribute to the development of cultural literacy as an integral component of biology education. Through these objectives, the study not only provides a synthesis of the existing body of knowledge but also highlights gaps and emerging themes that warrant further investigation. By doing so, it contributes to a deeper understanding of how cultural literacy can be framed, theorized, and advanced within biology education, offering insights that may support both scholars and practitioners in fostering more culturally responsive science teaching and learning.

METHOD

This study uses the Systematic Literature Review (SLR) method, which is a document-based research method characterized by a rigorous, standardized, and verifiable methodology. This approach ensures that the study is replicative, transparent, objective, bias-free, and comprehensive.[15] In this study, Scopus was selected as the sole database for article retrieval because it provides comprehensive coverage of peer-reviewed journals across disciplines, including education and biology. The search syntax used is as follows: "cultural literacy" OR "cultural awareness" OR "cultural competence" OR "multicultural literacy" OR "intercultural understanding") AND ("biology education" OR "science education" OR "environmental education" OR "life science education" OR "biology curriculum") AND ("school" OR "secondary education" OR "pre-service teachers" OR "students" OR "classroom").

RESULTS

Article Selection Process

The results begin with the description of the article selection process (figure 1). A total of 49 records were initially identified through the Scopus database. At the screening stage, 1 record was discarded because it was written in a non-English language (Russian, Chinese, Arabic, French, etc.), leaving 48 English-language articles. In the eligibility stage, 10 articles were excluded because they belonged to subject areas not aligned with the study focus, such as Humanities, Language and Literature, Area Studies, Politics and International Relations, Communication Studies, and Health and Social Care. This reduced the dataset to 38 articles in the Social Science domain. Next, only open access articles were considered, resulting in the exclusion of 13 paid articles and leaving 15 articles. A further assessment of abstracts and full texts led to the exclusion of 3 articles that were not relevant to the study theme. Thus, the final number of articles included in this review was 12, which formed the basis for the subsequent analysis.

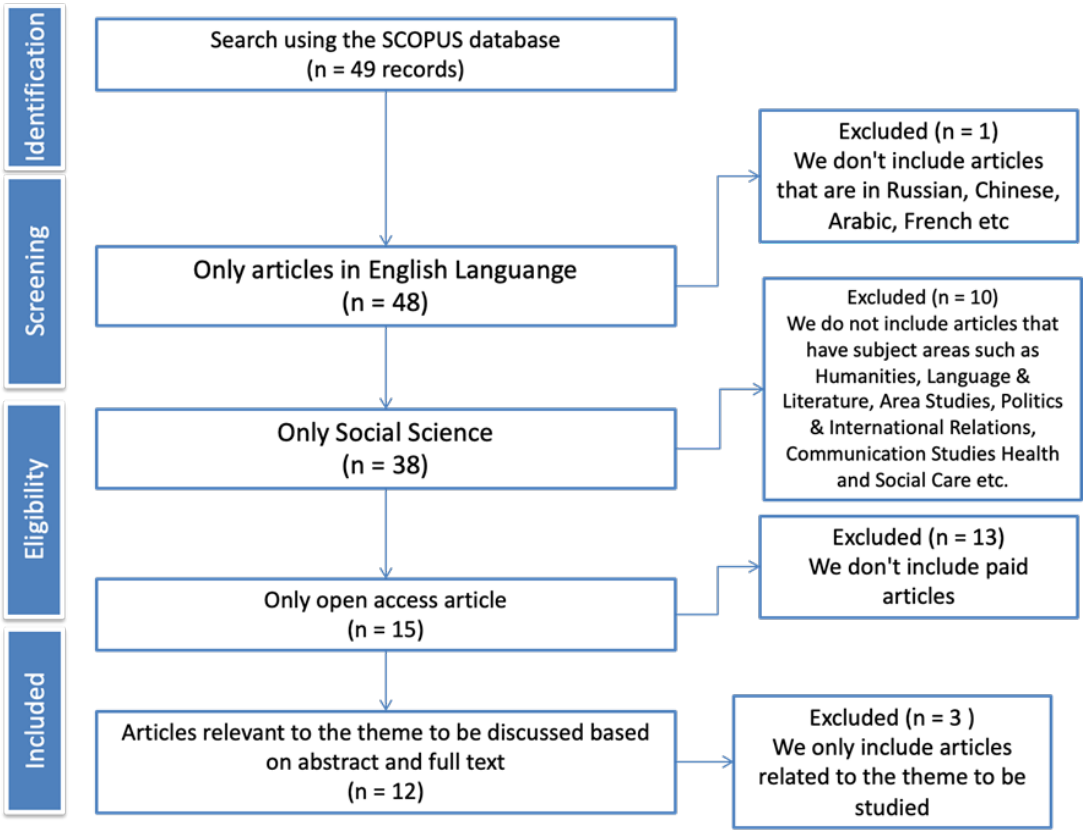

Figure 1. PRISMA DIAGRAM

The Main Elements That Focus on Cultural Literacy Research in Biology Education

Cultural literacy in biology education focuses on four main elements (table 1).

Table 1. Key Focus Elements and Research Findings on Cultural Literacy in Biology Education

No.	Key Focus Elements	Research Findings	Reference
1.	Integration of Local Cultural Values	The integration of local cultures improves students' understanding of ecosystems and conservation	(16,17)
2.	Development of Curriculum or Culture-Based Models	Community-based curriculum helps students and faculty understand science from their own social and cultural perspectives, not just from a western perspective.	(12,18,19)
3.	Strengthening Students' Cultural and Social Identity	Strengthening students' cultural identities strengthens their involvement in the classroom and increases confidence in explaining scientific concepts in a cultural context.	(20,21,22)
4.	Multicultural Competencies	The development of multicultural competencies is important for lecturers to be able to accommodate the diversity of students and create inclusive classrooms.	(23,24,25,26)

The Theories and Conceptual Approaches Used in The Study of Cultural Literacy in Biology Education

Various theories, such as CRT, social constructivism, funds of knowledge, and ethnopedagogy, are the basis for the study of cultural literacy in biology education (table 2).

Table 2. Theory and Conceptual Approaches in Cultural Literacy Research in Biology Education

No.	Theory/Approach	Research Findings	Reference
1.	Culturally Responsive Teaching (CRT)	Lecturers become more aware of the socio-cultural context of students.	(16,17,26)
2.	Social Constructivism	Local cultural experiences become a source of meaningful learning and strengthen understanding of science concepts.	(18,21,22,23,24)
3.	Ethnopedagogy & Ethnoscience	Connecting local knowledge with modern scientific concepts to improve students' cultural literacy.	(12,19,25,27)

The Directions and Potential of Future Research Related to Cultural Literacy in The Context of Biology Education

Four strategic directions can be used as a roadmap for future research (table 3).

Table 3. Future Research Directions and Potentials of Cultural Literacy in Biology Education

No.	Potential	Future research opportunities	Reference
1.	Development of Cultural Literacy Assessment Instruments	Design and test quantitative instruments for biology students and lecturers with high validity and reliability	(16,17)
2.	Integration in Biology Curriculum and Learning	Study of curriculum and design of local culture-based biology learning models that can be adapted on higher education	(12,18,19,21,25,26)
3.	Use of Culture-Based Media and Technology	Development of technology based on local ethnobiology and ecology to improve students' cultural and science literacy	(23)
4.	Correlation of Cultural Literacy with Ecological Attitudes	Quantitative or longitudinal research to measure the impact of cultural literacy on conservation attitudes, ecological behaviors, and love for the local environment	(20,22,24)

DISCUSSION

The integration of local cultural values into science learning, particularly in biology, has been shown to enhance students' understanding of ecosystems and conservation by grounding abstract concepts in contexts familiar to their everyday lives.[28] Moreover, the development of culture-based curricula allows both students and educators to interpret science through their own social and cultural perspectives rather than relying solely on Western paradigms. This approach also contributes to strengthening students' cultural and social identities, which, in turn, fosters greater classroom engagement and builds confidence in explaining scientific concepts within cultural frameworks. Furthermore, the development of multicultural competencies among educators is essential to accommodate student diversity and to create inclusive learning environments.[29,30,31]

Theoretical and conceptual approaches in cultural literacy research highlight the central role of social and cultural contexts in biology education. The application (CRT) increases the relevance and motivation of student learning by ensuring that lecturers are more aware of students' socio-cultural backgrounds. Social Constructivism emphasizes the importance of local cultural experiences as a meaningful foundation for learning and to strengthen students' understanding of scientific concepts. Ethnopedagogy and Ethnoscience approaches connect local knowledge with modern scientific concepts, enabling students to develop both ecological and cultural literacy.[17,22,25]

The findings also reveal a research gap in the development of assessment instruments and learning media oriented toward cultural literacy in biology education. The existence of valid and reliable instruments is essential for mapping the level of cultural literacy among students and lecturers, as well as for measuring the effectiveness of culture-based learning programs.[1] The use of culture-based learning technologies such as Augmented Reality (AR), digital applications, or interactive media that raise local content is still rarely found in the literature, this shows the need for innovation in the development of teaching tools that not only strengthen cognitive and affective aspects in biology learning, but also reflect the cultural context of students authentically and interestingly.[32]

The findings in this study show that a local culture-based approach in biology learning can build ecological awareness and conservation ethics in students. The values embodied in the traditions, local wisdom, and practices of indigenous peoples contain the principles of natural balance and sustainability, which are in line

with modern ecological principles.[2,33] Cultural literacy is not only positioned as a pedagogical tool, but also as an instrument to build a generation that is environmentally conscious and rooted in local values.[2,28] Advancing cultural literacy in biology education requires not only the integration of local cultural values and theoretical frameworks such as CRT, Social Constructivism, and Ethnopedagogy, but also the development of innovative assessment instruments and learning media. Such efforts will ensure that biology education becomes more contextually relevant, equitable, and capable of fostering both scientific understanding and cultural awareness among students.

CONCLUSIONS

The results of the analysis show that cultural literacy research in biology education has evolved towards a more humanistic approach, but still faces conceptual and methodological challenges. Although various theories such as Culturally Responsive Teaching, Social Constructivism, and Ethnopedagogy have been used, there is no unified conceptual framework that is able to measure and direct the systematic application of cultural literacy. Other limitations include the lack of valid assessment instruments and the lack of use of local technology-based and cultural media. It is emphasized that cultural literacy in biology education should be understood not merely as supplementary knowledge, but as a critical framework for fostering science learning that is contextual, inclusive, and responsive to diversity. Consequently, cultural literacy can be positioned as a strategic dimension in strengthening the relevance and sustainability of biology education in the future.

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CONFLICT OF INTEREST

There is no conflict of interest.

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