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REVIEW

Promoting Language and Scientific Literacy Through Children's Literature: A Systematic Literature Review

Promoción de la alfabetización lingüística y científica a través de la literatura infantil: una revisión sistemática de la literatura

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ABSTRACT

Children's literature is widely recognized for its potential to enhance student development. Despite existing research and publications on the topic, a thorough study on integrating children's literature into language and scientific literacy has not been widely conducted. This systematic literature review aimed to comprehensively explore current literature on innovative strategies and the effects of integrating children's literature to improve language and scientific literacy. Utilizing the Systematic Literature Review (SLR) and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methods, this review analyzed 54 studies from the Scopus database spanning 2010 to 2024. The Publish or Perish and VOSviewer applications supported the identification, screening, eligibility, and inclusion stages. Scopus-indexed articles totaling 275 were initially identified and filtered into 54 relevant pieces. The findings highlight that integrating children's literature into science education effectively bridges language and scientific literacy, enhancing cognitive development and comprehension. The potential of this interdisciplinary teaching model suggests practical applications for educators seeking to enrich their instructional strategies by employing diverse literary forms such as informational texts, biographies, comics, dramas, and science fiction. Ultimately, this review emphasizes children's literature's significant role in advancing language and scientific literacy in educational contexts.

Keywords: Children's Literature; Language Literacy; Scientific Literacy.

RESUMEN

La literatura infantil es ampliamente reconocida por su potencial para mejorar el desarrollo estudiantil. A pesar de la investigación y las publicaciones existentes sobre el tema, no se ha realizado un estudio exhaustivo sobre la integración de la literatura infantil en la alfabetización lingüística y científica. Esta revisión sistemática de la literatura tuvo como objetivo explorar de manera integral la literatura actual sobre estrategias innovadoras y los efectos de integrar la literatura infantil para mejorar la alfabetización lingüística y científica. Utilizando los métodos de Revisión Sistemática de la Literatura (SLR) y los elementos de informe preferidos para revisiones sistemáticas y metaanálisis (PRISMA), esta revisión analizó 54 estudios de la base de datos Scopus que abarcan de 2010 a 2024. Las aplicaciones Publish or Perish y VOSviewer apoyaron las etapas de identificación, selección, elegibilidad e inclusión. Inicialmente se identificaron y filtraron un total de 275 artículos indexados en Scopus, quedando 54 estudios relevantes. Los hallazgos

destacan que la integración de la literatura infantil en la educación científica une eficazmente la alfabetización lingüística y científica, mejorando el desarrollo cognitivo y la comprensión. El potencial de este modelo de enseñanza interdisciplinario sugiere aplicaciones prácticas para educadores que buscan enriquecer sus estrategias didácticas empleando formas literarias diversas como textos informativos, biografías, cómics, dramas y ciencia ficción. En última instancia, esta revisión enfatiza el papel significativo de la literatura infantil en el avance de la alfabetización lingüística y científica en contextos educativos.

Palabras clave: Literatura Infantil; Alfabetización Lingüística; Alfabetización Científica.

INTRODUCTION

The significance of children's literature in education has been extensively acknowledged for its significant impact on various aspects of student development.[1,2,3] This recognition has led the Indonesian Ministry of Education and Culture to launch a program to integrate literature into the curriculum, emphasizing the inclusion of children's literature across various disciplines. This integration aims to harness the power of children's literature to cultivate creativity, critical thinking, empathy, and a broader understanding of the world in young learners.[4,5,6] By weaving children's literature into the curriculum, educators can create a more engaging and holistic learning experience that nurtures well-rounded individuals prepared to navigate the complexities of the 21st century.[7,8] Children's literature, with its rich narratives and diverse genres, presents a unique opportunity to address educational challenges. Stories and informational texts can captivate students' imaginations, making learning an enjoyable and meaningful experience.[9,10] When integrated thoughtfully into the curriculum, children's literature can serve as a powerful tool to promote literacy by developing reading skills, expanding vocabulary, and encouraging critical thinking.[11,12] Additionally, children's literature that includes scientifically accurate information and themes can contribute to students' understanding of scientific concepts and the nature of scientific inquiry.[13,14]

Recent literature in science education has emphasized the need to improve learners' scientific literacy by teaching relevant concepts and practices.[15,16] Despite acknowledging the importance of concepts, educators often neglect teaching them in early elementary education, assuming that young children cannot comprehend them.[17,18] However, current research suggests that concept development can be nurtured in children through authentic and age-appropriate methods.[4,19] The emphasis on literacy instruction has led many schools to reduce time dedicated to content areas such as studies, with some even eliminating them from early-grade curricula. Teachers are under considerable pressure to prioritize literacy, often resulting in the integration of science and social studies into literacy instruction.[20,21] This typically involves incorporating science content into reading materials during literacy periods. However, there is a growing recognition of the importance of developing conceptual knowledge in early elementary education, observations indicate an imbalance in the school curriculum, with an excessive focus on stories and a lack of informational texts, particularly those related to science.[22,23] International science education policies stress the significance of scientific literacy, emphasizing the need for students to understand the processes of science and the knowledge it generates, and to apply this understanding in everyday situations.[24,25] It is important to note that scientific literacy is not solely about a child's ability to read and write about science or understand scientific terminology, rather it encompasses a broader understanding and engagement with scientific concepts and principles.

Children's literature plays a crucial role in nurturing various aspects of a child's development, as highlighted in some research. Some research has highlighted the pivotal role of children's literature in fostering self-understanding, empathy, language appreciation, and critical thinking.[2,26,27] Other key research also explored its instructional use for younger students and the presence of gender stereotypes in these texts.[28] May et al. [29] emphasized the significance of grasping the changing nature of science trade books, focusing on aspects like language, text structures, and design. Their study underscores the need for diverse text structures in educational settings to enhance scientific comprehension, especially for young learners. Despite these insights, research on integrating children's literature into language and scientific literacy remains limited. This study aims to: (1) synthesize existing knowledge on the connections between children's literature, literacy, and scientific literacy; (2) identify the strategies for integrating children's literature; and (3) evaluate the impact of children's literature on language and scientific literacy.

METHOD

Research Design

This research employs the Systematic Literature Review (SLR) method, specifically adopting the Kitchenham model, to uncover findings, studies, and analyses of innovative approaches that integrate children's literature

to enhance language and scientific literacy.[30] The SLR process begins with identifying recent literature relevant to children's literature, literacy, and scientific literacy using the Publish or Perish tool on Scopus databases. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) technique is utilized to guide the SLR procedure through the stages of identification, screening, testing eligibility, and data inclusion. Following this, an analysis is conducted, and the findings are presented in a descriptive format. The PRISMA technique ensures systematic identification, screening, and inclusion of recent articles indexed by Scopus.

Inclusion and Exclusion Criteria

Researchers established six criteria for selecting articles: (a) the articles had to be peer-reviewed scientific articles, excluding literature findings in papers, book chapters, conference proceedings, research reports, books, dissertations, and theses, (b) the articles needed to be indexed in the Scopus database, with a publication date range from 2010 to 2024, (c) the articles had to be written in English, (d) the Publish or Perish application was exclusively used for article searches, (e) only complete PDFs of the literature were considered, and (f) the articles needed to be published in open-access journals.

Screening and Eligibility Assessment for Data Analysis

At this stage, on May 31, 2024, researchers screened literature findings from Scopus using the Publish or Perish tool. The screening process focused on the title, abstract, and keywords of the articles. Various keywords were employed to ensure a sufficient selection of articles. The search of the Scopus database yielded 275 published articles for the period 2010-2024. The details of the keywords and the number of the article are provided in table 1 below.

Table 1. Results of Article Searches from the Scopus Database

Keywords	Number of Articles
Children literature, literacy, scientific literacy	92
Information book, literacy, scientific literacy	77
Science fiction, literacy, scientific literacy	30
Comic, literacy, scientific literacy	17
Drama, literacy, scientific literacy	17
Poetry, literacy, scientific literacy	15
Storybook, literacy, scientific literacy	21
Story tale, literacy, scientific literacy	6
Total	275

The initial search yielded 275 articles (see table 1), but not all were selected for review. Instead, a refined selection process led to 54 articles being chosen. These articles were then imported into the Mendeley application and saved as an RIS file. The initial thematic relevance network was mapped by importing the RIS file from Mendeley into the VOSviewer application, version 1.6.20. The following steps were followed to import the RIS file into VOSviewer: (1) prepare the RIS file, (2) generate a map using bibliographic data, (3) load data from the reference manager file, (4) select the file from the computer, (5) specify the analysis type and counting method, specifically: co-occurrence analysis, unit of analysis as keywords, and complete counting method, (6) verify selected keywords, and (7) finalize and present the results.

The initial analysis of thematic associations reveals a highly intricate pattern of connections concerning the theme of children's literature within the realms of literacy and scientific literacy. This complexity is depicted in the network visualization displayed in figure 1 below.

Figure 1 shows that the study of children's literature in the context of literacy and scientific literacy is closely related to several themes such as literacy, science education, literature, and scientific literacy. Some keywords that have a distant connection to the theme of the study are literature, science, children literature, and scientific literacy.

PRISMA Flow Diagram

The article search process utilizes the PRISMA flowchart, employing four stages: identification, screening, eligibility, and inclusion. These stages are illustrated in figure 2 below.

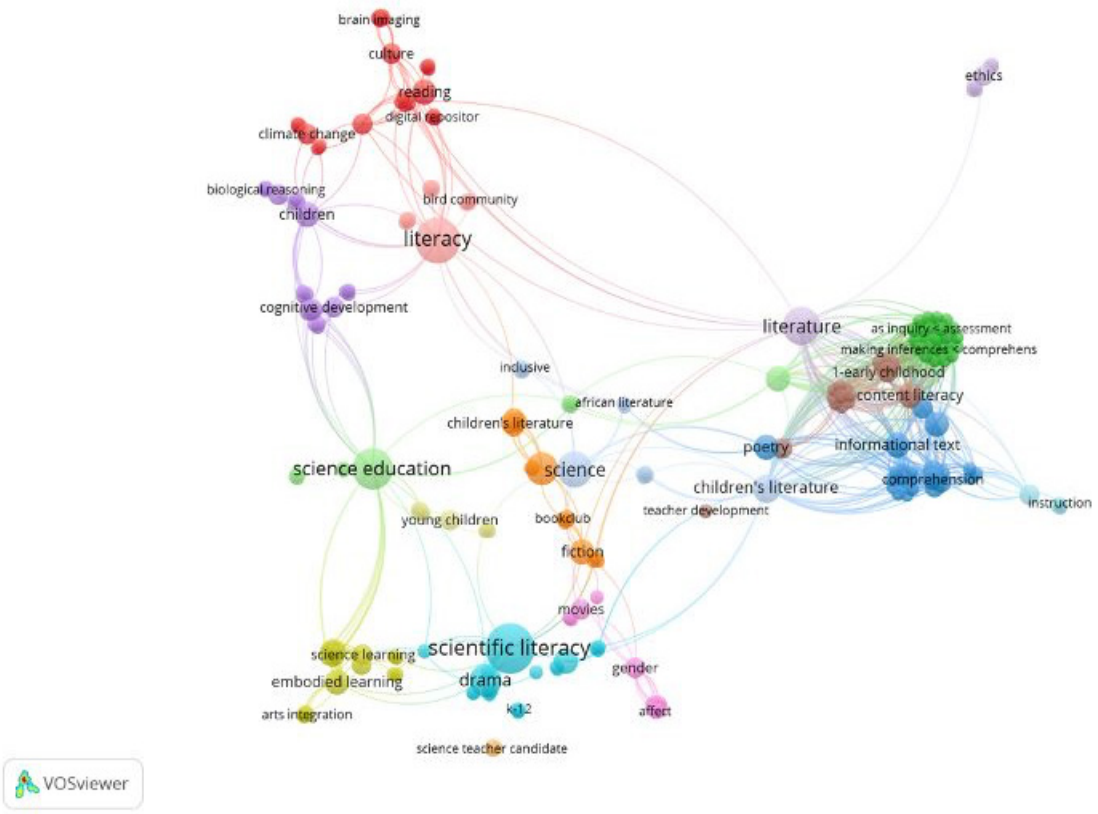

Figure 1. Network Visualization Based on Keywords

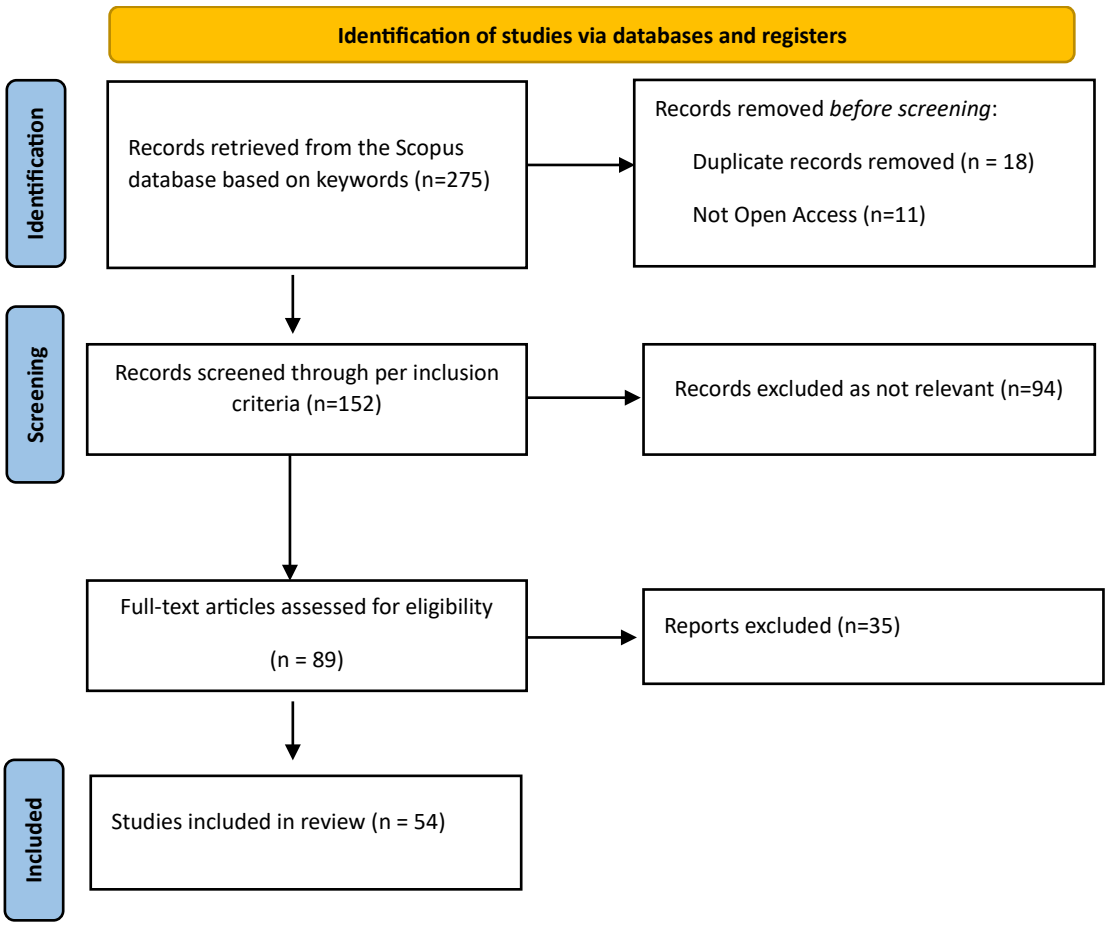

Figure 2. The PRISMA Flow Diagram

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During the identification stage, a total of 275 articles indexed in Scopus were initially discovered using the Publish or Perish tool (see table 1). Subsequently, at the screening stage, these articles underwent a keyword-based assessment, resulting in the identification 18 similar articles and 11 articles not open access, while 152 distinct articles were retained. The determination of similarity was based solely on the keywords utilized, as the search was confined to the Scopus databases. Following this screening, 94 irrelevant articles were excluded, leaving 89 articles for further consideration. Upon reaching the eligibility stage, 89 articles were selected for comprehensive reading, while 94 articles were discarded. Finally, 54 articles were chosen from the 89 eligible articles, aligning with the research questions and meeting the criteria of relevance in terms of title, abstract, keywords, and content, while the remaining 35 articles were not utilized.

RESULTS

This section presents the findings extracted from 54 articles, organized by journal details, author names, titles, and their relevance to the Research Questions (RQ). The research questions include RQ 1 - The connections between children's literature, literacy, and scientific literacy; RQ 2 - Strategies integrating children's literature to enhance language and scientific literacy; and RQ 3 - The impact of children's literature on students' language and scientific literacy. The detailed identification results are presented in table 2.

Table 2. The findings of 54 articles from Scopus databases

No	Journals	Authors (Year)	Sources	RQ
1.	Applied Mathematics and Nonlinear Sciences	Fu (2024)	(31)	1
2.	Natural Sciences Education	Wayne et al. (2024)	(32)	2
3.	Contemporary Trends and Issues in Science Education	Namdar et al. (2024)	(33)	2,3
4.	Eurasia Journal of Mathematics, Science and Technology Education	Fitria et al. (2023)	(34)	2
5.	Cham: Springer International Publishing.	Turkka et al. (2023)	(35)	2
6.	International Journal of Science and Mathematics Education	Archila, Restrepo, et al. (2023)	(36)	2,3
7.	Science and Education	Archila, Truscott de Mejía, et al. (2023)	(37)	2,3
8.	Early Childhood Education Journal	Gibbs & Reed (2023)	(38)	1,3
9.	Invertebrate Biology	Wonham & Wasson (2023)	(39)	2
10.	Science and Education	Ampatzidis & Ergazaki (2023)	(4)	2,3
11.	Journal of College Science Teaching	Cook & Wheeler (2023)	(40)	2
12.	Educacao e Pesquisa	Castro et al. (2023)	(41)	1
13.	PLoS ONE	Adler et al. (2022)	(42)	3
14.	Canadian Journal of Science, Mathematics and Technology Education	Smith & Cavagnetto (2022)	(43)	2
15.	Journal of Research in Science Teaching	Varelas et al. (2022)	(44)	2
16.	Lumat	Turkka & Aksela (2022)	(45)	2
17.	Jezik in Slovstvo	Haramija (2022)	(46)	3
18.	Research in Science Education	Murphy et al. (2021)	(24)	1,3
19.	Research in Science Education	Matuk et al., (2021)	(47)	2,3
20.	Information Visualization	Walsh et al. (2021)	(48)	2,3
21.	Science and Drama: Contemporary and Creative Approaches to Teaching and Learning	Baskerville & Anderson (2022)	(49)	2,3
22.	Springer	White et al. (2021)	(50)	1,2,3
23.	FEMS Microbiology Letters	Verran (2021)	(51)	2
24.	Reading Research Quarterly	May et al. (2020)	(29)	2
25.	Literacy	Dernikos & Thiel (2020)	(52)	2
26.	International Journal of Evaluation and Research in Education (IJERE)	Matamit et al. (2020)	(5)	2,3
27.	The Wiley Handbook of Early Childhood Care and Education	Akerson (2019)	(53)	3
29.	História, Ciências, Saúde – Manguinhos	Bettini & Fernandes (2019)	(54)	2
30.	Revista Brasileira de Educação Especial	Shimazaki et al. (2018)	(55)	2
31.	Contributions from Science Education Research	Peleg et al. (2018)	(56)	2
32.	SAGE Open	Menadue & Jacups (2018)	(57)	2
34.	Journal of Research in Science Teaching	Emmons et al. (2018)	(58)	3

35.	Global Developments in Literacy Research for Science Education	Ødegaard (2018)	(59)	1,3
36.	Science and Education	Archila (2017)16–30 years old	(60)	2
37.	International Perspectives on Inclusive Education	Blake & Roberts (2017)	(61)	1,3
38.	Reading Teacher	Kersten (2017)	(62)	1,3
39.	Kinesiology Review	Gleaves (2017)	(63)	1
40.	Kuram ve Uygulamada Egitim Bilimleri	Önen Öztürk (2017)	(65)	2
41.	Springer International Publishing	Diamond & Powell (2016)	(66)	1,2
42.	AJOB Neuroscience	Grubbs (2016)	(67)	2,3
43.	American Biology Teacher	Boswell & Seegmiller (2016)	(68)	1,3
44.	Reading Teacher	Frye et al. (2016)	(69)	2,3
45.	Research in Early Childhood Science Education	Smolkin & Donovan (2015)	(22)	1,3
46.	Reading Teacher	Hoffman et al. (2015)	(19)	1,3
47.	The Journal of Educational Research	Tong et al. (2014)	(70)	1,3
48.	Mediterranean Journal of Social Sciences	Adika & Klu (2014)	(71)	2
49.	Psychological Science	Kelemen et al. (2014)	(72)	2,3
50.	Theory into Practice	Mantzicopoulos & Patrick (2011)	(73)	2
51.	Science Communication	Barriga et al. (2010)	(75)	2
52.	Asia-Pacific Forum on Science Learning and Teaching	Pongsophon et al. (2010)	(76)	2
53.	Journal of Research in Science Teaching	Varelas et al. (2010)	(77)	2
54.	Ecotoxicology	Stewart (2010)	(78)	2

DISCUSSION

RQ 1: Connections between children's literature, literacy, and scientific literacy

The world of children's literature offers a vibrant landscape for fostering both language and scientific literacy.[9,69,79] Research indicates strong connections between science and language proficiency.[14,41] The primary rationale behind merging science and language arts in educational practices stems from compelling evidence highlighting cognitive similarities between these two domains.[80] This aligns with a sociocultural perspective that integrates Vygotsky's belief in the crucial role of language in learning, thus making science and language arts naturally complementary for integrated instruction.[81,82] Proficiency in language literacy can stimulate students' cognitive abilities as it not only improves language skills but also contributes to overall knowledge enhancement.[83] Numerous studies have revealed the close connection between early literacy and language development in children and the attainment of proficient reading and writing skills in later stages.[66,84,85] Literacy during the early years is regarded as a pivotal element in enhancing language acquisition and cognitive abilities. Children with a poor literacy foundation before entering formal schooling are at a higher risk of encountering academic difficulties.

Engaging children with literature depicting natural environments alongside scientific learning fosters a strong connection between scientific education and literacy development.[28,61] Science texts play a significant role in education.[22] Integrating literacy activities into science inquiry supports effective science teaching and learning.[53,62] Additionally, students' verbal communication during inquiries reveals a progression from word knowledge to conceptual understanding when they are prompted to apply key concepts throughout the inquiry process.[59] Children's literature aids in the development of letter-sound associations and early vocabulary acquisition in children aged 4 to 6.[66] Furthermore, primary education students develop phonological awareness through appropriate children's literature corresponding to their literacy development stage. Early exposure to science activities featuring rich verbal and nonverbal content results in the formation of substantial reservoirs of knowledge, which are then organized into robust conceptual frameworks.[86] The use of scientific language can shape young children's understanding and thought processes.[22] Although some scientific concepts may be challenging for young learners, proper instruction can facilitate their development of scientific understanding. Importantly, scientific thinking can begin from infancy, emphasizing the significance of starting science education early in life.

Children's literature not only offers enjoyment but also provides a rich and immersive experience that nurtures a passion for reading, promotes critical thinking abilities, facilitates the development of essential skills, and introduces scientific concepts in an engaging and accessible manner.[63] Literacy defined as the ability to read and write effectively, is a fundamental skill that underpins all academic learning.[43] With a strong focus on literacy during elementary education, the fusion of language arts and science emerges as a crucial avenue for students to grasp scientific concepts.[70] Scientific literacy, on the other hand, refers to the understanding of scientific concepts and processes necessary for personal decision-making, participation in civic and cultural affairs, and economic productivity. Despite the acknowledged importance of both literacy and

scientific literacy, there is a growing concern about students' proficiency in these areas. Recent educational assessments have highlighted significant gaps in students' reading comprehension and scientific understanding. These gaps point to a need for innovative educational strategies that can effectively engage students and enhance their learning outcomes.

RQ 2: Strategies Integrating Children's Literature to Enhance Language and Scientific Literacy

Professional development interventions have been shown to effectively modify instructional practices among educators, leading to substantial improvements in children's literacy skills.[66] Notably, interdisciplinary approaches combining science and literacy objectives have attracted significant scholarly attention, particularly in using children's literature for science learning and enhancing verbal interactions between teachers and students.[53] The synthesis of 54 articles highlights several strategies for integrating children's literature into learning, as outlined below.

a. Integrating Science in Picture Storybooks

Integrating picture storybooks into educational settings has been shown to significantly enhance both language and scientific literacy among young learners. Research by Kelemen et al.[72] demonstrated that even children as young as four can grasp fundamental concepts of natural selection when presented in an engaging narrative, which enhances their understanding and retention of these concepts. Emmons et al.[87] further reinforced these findings, showing that story-based learning not only captivates children's interest but also facilitates their ability to articulate and apply principles of natural selection. Additionally, Brown et al.[88] highlighted that such narrative-based interventions lead to significant improvements in children's conceptual understanding, suggesting that these techniques are effective tools for teaching complex scientific ideas. Teaching using science picture books combining visual elements with narrative makes complex information more accessible to young learners and fosters curiosity and inquiry as part of early literacy practices.[73] Moreover, exposure to informational texts, including picture books, enhances children's comprehension skills and promotes critical thinking about scientific topics.[2,89] Yopp & Yopp[90] further support the effectiveness of interactive reading sessions in increasing engagement and retention of scientific knowledge. However, as noted Emmons et al.[87], the educational impact of these texts depends on the quality of illustrations and the alignment of the narrative with scientific accuracy. The integration of visuals in storybooks not only simplifies complex information but also aids memory retention, making scientific concepts more accessible and engaging for young learners.[48] Through careful selection and presentation, picture-storybook interventions can effectively teach basic concepts like natural selection, promoting successful comprehension, generalization, and retention.[72]

b. Informational Text Read-Alouds

During classroom read-aloud, children's verbal contributions provide valuable insights into their understanding of scientific concepts, making these sessions crucial for concept development.[19] Informational texts, which are specifically designed to impart knowledge, are particularly effective in enhancing this development during read-aloud. To maximize the benefits for both literacy and science concept development, teachers should carefully plan read-aloud sessions with texts that align with specific scientific learning objectives.[11] This planning involves selecting texts that support concept learning goals and identifying key vocabulary, challenging areas of the text, and text structures essential for comprehension. During the read-aloud, teachers guide discussions and model thinking aloud to aid students' understanding and facilitate deeper concept development. Additionally, by engaging students in read-aloud of various trade books that reinforce related scientific concepts, teachers can foster discussions that deepen students' understanding of themes and constructs, further solidifying their grasp of the material.

c. Story Telling

Storytelling is a powerful educational tool that organizes information and engages learners by fostering imagination, emotion, and truth across various subjects. For children, storytelling enhances imaginative skills, particularly when considering diverse cultural backgrounds, making it a valuable asset in elementary education.[5] It not only boosts engagement, creativity, literacy, and language skills but also supports a deeper understanding of complex concepts. For instance, participants who read narrative texts demonstrated a greater understanding of evolution compared to those who read expository texts, highlighting the effectiveness of storytelling in education.[42] Storytelling further amplifies these benefits by offering educators a dynamic way to engage students, especially those who may struggle in traditional learning environments. This approach disperses narrative elements across multiple media platforms, creating an integrated and coordinated storytelling experience that challenges students to expand the lore and mythology of the overarching narrative, thereby fostering problem-solving skills.[91] Transmedia storytelling not only enhances literacy learning but also connects with students on different sociocultural levels, making learning more engaging and meaningful.[52] Through this

method, educators can reconceptualize literacy and learning, providing students with opportunities to create and explore stories beyond traditional boundaries, ultimately shaping a more optimistic future for all learners.

d. Using Biographies of Scientists

Biographies have emerged as a highly effective resource for representing the nature of science.[43,92] These biographies provide students with valuable insights into the lives and work of scientists, offering real-life examples of scientific inquiry and discovery. By exploring the personal and professional journeys of scientists, biographies offer a rich context for understanding the iterative and collaborative nature of science, the importance of perseverance in scientific endeavors, and the ethical considerations involved in scientific work. Through these narratives, students not only learn about the contributions of specific scientists but also develop a deeper appreciation for the scientific process and its profound impact on society.

e. Reading Science Fiction and Fantasy

Incorporating fiction into the curriculum, as suggested by Boswell & Seegmiller[68], can significantly enhance both overall literacy and scientific literacy. Fiction allows students to engage with scientific concepts creatively and emotionally, leading to deeper understanding and retention. By exploring "what if" scenarios and expressing their beliefs, students develop critical thinking skills, engage in richer discussions, and foster a lifelong interest in science and literature. However, science texts for young children, particularly those that merge storytelling with scientific information, present challenges due to their complexity, potentially leading to misconceptions rather than effective learning.[22] Additionally, fiction has been shown to be effective in educating and engaging the public on complex topics like infectious diseases, demonstrating its potential in promoting science communication and enhancing public awareness.[51] The interdisciplinary potential of fiction is further emphasized by Grubbs[67], who argues for more collaborative work that crosses the boundary between the humanities and sciences, suggesting that including a humanist in the experimental process could enhance various stages of scientific inquiry. These studies highlight the significant role that fiction, particularly science fiction and fantasy, plays in engaging readers with science, technology, and ethical considerations, fostering a positive relationship between these genres and readers' attitudes toward science.[57]

f. Watching Science Fiction Movies

The potential of fiction, including science fiction television, as a medium for science communication is further underscored by its ability to shape viewers' perceptions and understanding of science.[93] Preliminary findings from an online survey on Science Fiction & Fantasy reveal that the genre attracts a diverse audience with varying attitudes toward science.[54] In addition to fostering scientific literacy, science-fiction movies also contribute to language development and creative thinking. According to Vygotsky, creative activity arises from the interplay between fantasy and reality, meaning that the more varied experiences children have, the broader their repertoire becomes.[74] By watching diverse films, students not only enhance their language skills but also cultivate their ability to connect real-life experiences with the realm of imagination, which is a crucial component in the learning and growth process.

g. Using Science Trade Books

Science trade books are non-fiction publications designed to present scientific subjects in an engaging and accessible manner, catering to a broad readership, including children. Unlike conventional science textbooks, which typically prioritize the delivery of scientific content in a formal and structured format, trade books aim to captivate readers by conveying scientific facts in a relatable and comprehensible way. These books often focus on communicating scientific information such as details about diverse animal species or explanations of natural phenomena like tornadoes.[43] The study highlighted the importance of understanding the evolving nature of science trade books, particularly in terms of language, text structures, and book design. It explored various genres within science trade books, including traditional survey books, biographies of scientists, and narratives about the lived experiences of scientists. The research also emphasized the need for educators to provide access to a variety of text structures to support scientific understanding in classrooms, especially for young children.[29] This approach helps foster a deeper connection to the material, making science more accessible and engaging for students.

h. Composing Informational Poetic Riddles

The relationship between science and poetry has been symbiotic since ancient times, with poets often drawing on scientific phenomena as legitimate subjects for their work. Many poets have also been practicing scientists, using their professional experiences and scientific terminology to convey their poetic intentions.[78] Recent research highlights the potential of science-oriented poems as tools for enhancing literacy. Studies by Stewart suggest that integrating poetry into science education can foster engagement and improve

comprehension of complex scientific concepts. Similarly, Adika & Klu[71] research shows that students who engage with science-themed poetry develop improved vocabulary and critical thinking abilities, indicating a positive correlation between poetic expression and literacy development. However, the successful implementation of such interdisciplinary approaches in education requires structured teacher training to maximize the benefits of integrating poetry into science curricula.[94]

Thesis poetry, which combines elements of science and poetry, offers a unique format for communicating scientific concepts to a broader audience. By blending empirical logic from scientific principles with personal intuition and emotions, thesis poetry expresses the human side of scientists, often overlooked in traditional scientific articles. This creative form of expression helps bridge the gap between scientists and the general public, making complex scientific information more engaging and accessible. By summarizing scientific papers in a more narrative and expressive form, thesis poetry enhances storytelling in science communication, fostering better understanding and empathy for scientific topics among non-experts.[95]

i. Integrating Comics in Science Learning

The integration of digital comics in science education has been highly effective in enhancing both language and scientific literacy. Tools like Cartoon Story Maker simplify complex concepts, such as energy conservation, making them more accessible and engaging for students.[34] Visual elements play a crucial role in this process, as they not only simplify information but also aid in memory retention, making scientific content more appealing and easier to understand.[48] Comics also broaden student participation in science by making learning more inclusive and promoting a diverse approach to science literacy.[32,47] Teachers can diversify their teaching strategies by incorporating educational comics, leading to more effective classroom learning.[96] Furthermore, research indicates that comics are particularly beneficial for students with intellectual disabilities, fostering empathy, creativity, and social skills while improving academic and behavioral outcomes, especially for those with conditions like Down Syndrome.[55,97,98] Thus, integrating comics into educational practices offers a powerful tool for supporting both academic achievement and social development in students.

j. Drama Performance

Drama has emerged as a valuable tool in science education, significantly enhancing student engagement, motivation, and scientific literacy.[56] Research has shown that cross-curricular drama activities, such as role plays, enable students to acquire affective, cognitive, and procedural knowledge, bridging the gap between theoretical concepts and practical understanding in science.[33,60] Dramatization of complex scientific ideas, as demonstrated in plays like "The Blegdamsvej Faust," makes new concepts more accessible and familiar, promoting meaningful learning experiences.[56] Drama activities also support the development of critical thinking, ethical awareness, and argumentation skills, particularly in addressing socio-scientific issues.[36] By creatively engaging students in role-playing and narrative explorations, drama fosters a deeper understanding of science, making it more relatable and relevant to real-world contexts.[37]

Moreover, drama in science education has been recognized for its potential to foster character development and social skills, which are essential for responsible citizenship in the 21st century. By positioning students as expert scientists or involving them in fictional argumentative interactions, drama helps them develop empathy, creativity, and the ability to consider multiple perspectives on complex issues like climate change.[44,76] Despite the challenges of varying student participation and the need for teacher training, drama remains a powerful pedagogical resource that enriches science education by intertwining emotional sensitivity, cognitive development, and social interaction.[45] This holistic approach not only enhances scientific literacy but also prepares students to engage thoughtfully and responsibly with the scientific challenges of our times.[49,50]

k. STEAMiest poems

The growing enthusiasm for STEAM (Science, Technology, Engineering, Arts, and Mathematics) initiatives highlights the immense potential for inquiry and integration between the arts and sciences. A prime example of this interdisciplinary approach is biologically informed poetry, which requires careful illustration and translation to effectively communicate scientific concepts across linguistic and cultural barriers, maintaining its STEAM effectiveness.[39] Historically, the relationship between science and poetry has been symbiotic, with poets frequently drawing on scientific phenomena as their subject matter. Many poets, who were also scientists, leveraged their professional experiences and scientific terminology to express their creative intentions, illustrating the deep connection between these two fields.[71] This intersection of science and poetry continues to evolve, offering rich opportunities for creative exploration and education.

l. Fiction Talk Stories

The use of "fiction talk stories" in education presents a powerful approach to exploring the Nature of Science (NOS), particularly by emphasizing the historical evolution and fluidity of scientific knowledge. Narratives such

as "Inspiration cannot wait" and "Panta rhei," which delve into the history of concepts like the super-organismic-plant-community, effectively engage students by illustrating essential NOS elements, including creativity, the distinction between observation and inference, and the provisional nature of scientific understanding.[4] By carefully analyzing the key features and storytelling techniques of these narratives, educators can foster a more comprehensive and nuanced grasp of NOS, thereby enhancing students' overall scientific literacy. Recognizing that the Nature of Science is a fundamental aspect of scientific literacy,[99] these narratives serve as valuable tools in cultivating a deeper appreciation of how scientific knowledge is constructed and refined over time.

RQ 3: The Impact of Children's Literature on Students' Language and Scientific Literacy

Children's literature plays a significant role in enhancing both language and scientific literacy. Research indicates that engaging narratives and age-appropriate vocabulary in children's books stimulate curiosity and inquiry, which are essential for scientific understanding. Adler et al.[42] underscore the widespread use of children's literature and its positive impact on cognitive development, particularly in engaging children with scientific topics. Similarly, Haramija[100] & Kim et al.[101] emphasize the value of creative nonfiction in bridging scientific subjects with literary works, providing students with a multidimensional understanding of scientific concepts. Frye et al. [69] advocate for integrating language arts and science, asserting that this approach leads to greater achievement in both content areas among students. Ødegaardwhich aimed to continually improve a teaching model of integrated science inquiry and literacy instruction in collaboration with practicing science teachers (six primary teachers and their students[59] discusses how students' comprehension and conceptual knowledge of science improve through verbal communication during inquiries, while Akerson[53] supporting interdisciplinary approaches that combine science and literacy, noting the importance of leveraging teachers' strengths in literacy instruction to enhance science education. Moreover, Selfa[28] emphasizes the role of children's literature in improving reading and writing skills, particularly in fostering scientific literacy among primary education students. Blake & Roberts[61] highlight the transformative impact of combining literature with hands-on inquiry, which facilitates cognitive growth and enhances scientific knowledge among children. Fu[31] further explores the educational role of children's literature in character development and aesthetic literacy, emphasizing its significance in shaping cultural traditions. Overall, the integration of children's literature into science education fosters engagement, comprehension, and holistic development among students.

In children's literature education, educators are increasingly focused on nurturing aesthetic literacy alongside imparting fundamental knowledge, especially in light of ongoing educational reforms. Recognizing the significant role that children's literature plays in shaping the character and cultural identity of future generations, educators advocate for a holistic approach that emphasizes personality development and national character, viewing literature through the lens of cultural traditions and identity.[31] Children's literature, which spans genres like songs, poems, fairy tales, fables, essays, and stories, offers diverse avenues for educational exploration. Research suggests that while fictional narratives can aid memory recall, they may also lead to misconceptions.[74] However, literature remains a powerful tool for cognitive development and engaging children in scientific topics.[42] Books, including creative nonfiction, can introduce scientific concepts, stimulate scientific thinking, and help dispel misconceptions that might impede future learning.[58,72] For example, storybooks and animated narratives have been shown to effectively convey complex scientific ideas, such as natural selection, to young children.[4] Integrating literacy into science inquiry enhances students' conceptual understanding by connecting literacy skills with scientific concepts, fostering communication, and developing multiple literacies.[59] This interdisciplinary approach, which combines science with literature and encourages a sense of wonder, supports diverse learners and promotes scientific literacy through engaging and inclusive educational practices.[61] Overall, integrating science and literacy not only improves academic performance but also enhances students' understanding and retention of complex concepts, fostering a lifelong interest in both fields.[69,70]

In the other hand, engaging students in science inquiry not only enhances their literacy skills but also deepens their conceptual understanding, particularly when English language arts and science are integrated. This approach enables students to author multimodal nonfiction science books, which helps them grasp both nonfiction genres and scientific concepts more effectively.[62] Collaborative science inquiry systems have shown promise in promoting students' conceptual understanding and engagement in progressive inquiry activities. Educators advocate for using literature that promotes scientific inquiry and accurately reflects the nature of science, steering clear of perpetuating scientific myths. Inquiry-based learning further transforms teaching by encouraging students to ask big questions, connect their interests with the required content, and make learning relevant and exciting, aligning with recent educational reforms that emphasize inquiry practices in science education to build competencies for productive engagement with scientific knowledge, leading to increased motivation, enhanced learning, and improved reasoning skills.

CONCLUSIONS

The findings underscore the integral relationship between children's literature, literacy, and scientific

literacy, revealing how early engagement with literature can significantly enhance language development and scientific understanding. The integration of science and language arts in educational practices is supported by cognitive similarities between these domains, which align with Vygotsky's sociocultural perspective that emphasizes the role of language in learning. This integration fosters not only language proficiency but also cognitive growth, preparing children for academic success. Strategies such as the use of picture storybooks, informational text read-alouds, storytelling, biographies of scientists, and science fiction enhance students' engagement and retention of scientific concepts while simultaneously developing their literacy skills. Each strategy demonstrates how children's literature can make complex scientific ideas more accessible, engaging, and memorable for young learners. For instance, story-based learning, science-themed poetry, and digital comics have been shown to improve vocabulary, critical thinking, and memory retention, making scientific literacy more inclusive and appealing. The impact of children's literature on students' language and scientific literacy is profound. Engaging narratives and age-appropriate content stimulate curiosity and inquiry, essential for scientific understanding. Integrating language arts with science not only improves academic performance but also enhances students' comprehension and retention of complex concepts. This interdisciplinary approach supports diverse learners, promotes scientific literacy, and fosters a lifelong interest in both literature and science.

Overall, children's literature serves as a powerful tool in education, bridging the gap between language and science, and laying a strong foundation for future academic success. The emphasis on aesthetic literacy alongside fundamental knowledge underscores the holistic benefits of integrating literature into science education, contributing to the development of well-rounded, scientifically literate individuals.

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The authors declare that there is no conflict of interest.

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