

Emerging Trends in Early Childhood Science Education: Pedagogies and Insights from a Systematic Literature Review

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Abstract

The purpose of this study is to systematically identify and analyze global research trends in early childhood science education for children aged 3-8 years, focusing on prevalent instructional approaches and their effectiveness. A systematic literature review was conducted following the PRISMA guidelines. The Scopus database was queried for relevant, accredited articles published between 2015 and 2025. After applying strict inclusion criteria, a final corpus of seven key publications was selected for in-depth qualitative analysis to identify dominant themes and patterns. This review provides a synthesized analysis of the most recent and impactful pedagogical strategies in early childhood science education. It confirms the dominance of concrete, experience-based learning and reveals the significant effectiveness of role-playing and multimodal visualization techniques in making abstract scientific concepts accessible to young learners. A key novel insight is the identification of critical contextual factors for successful implementation, highlighting that teacher acceptance of new methodologies is highest when they align with existing pedagogical values and daily practices. Furthermore, the study underscores the influential role of the teacher and the intentional design of the learning environment in fostering scientific engagement. The primary contribution is a clear, evidence-based argument for developing holistic, play-based, and contextually relevant curricula. These findings offer a foundational framework for educators, researchers, and policymakers to design effective, developmentally appropriate, and engaging science learning strategies for the modern era

Keywords: Early Childhood; Pedagogy; Research Trends; Science Education; Systematic Literature Review

INTRODUCTION

The rapid development of science and technology demands that science learning be introduced from an early age. Early Childhood Education has a strategic role in building the foundation of critical, logical, and creative thinking through concrete and meaningful science activities. The goal of early childhood education is essentially to maximize children's potential and role as future individuals. This potential can be stimulated through guided interactions between children and their environment.

Early childhood represents a foundational stage of human development, characterized by rapid growth in physical, cognitive, and emotional domains (Bentri & Rahmi, [2017](#); Prasetya, Lisnasari, Gajah, Karo Sekali, & Rahman, [2022](#); Tang, Dhamotharan, & Abdul Rahman, [2021](#)). The implementation of comprehensive, evidence-informed educational strategies during this period is crucial for maximizing a child's developmental potential and establishing a strong basis for lifelong learning (Ma, [2023](#)). According to Vygotsky ([1980](#)) theory, children's active interaction with their environment is crucial for cognitive (Yogi, [2023](#)) and language development

(Efstathiadi, [2019](#)), making experiential science learning highly relevant for early childhood (Astuti, Nazhifa, & Azizah, [2021](#); Prachagool, [2021](#)). Children's experiences can influence the life experiences they gain from their environment, so appropriate steps are needed to prepare children from an early age. Science learning in early childhood education not only aims to introduce basic scientific concepts but also fosters curiosity, observational skills, and problem-solving skills from an early age (Golob & Ungar, [2025](#); Grist, Caudle, Quesada-Pallarés, & Thompson, [2023](#)). Information processing theory, developed by scholars such as George A. Miller and Herbert A. Simon, investigates the mechanisms by which children encode, store, and retrieve information. This viewpoint asserts that children actively build understanding through cognitive processes, with cognitive development characterized by improvements in attention, memory, and problem-solving abilities. This approach offers educators a framework for crafting science activities that effectively engage growing cognitive talents (Archer, Dewitt, & Osborne, [2015](#); Nafiqoh & Wulansuci, [2021](#); Nurani, Niken Pratiwi, Situmorang, & Ni Gusti Ayu Made Yeni Lestari, [2024](#)). Practical application involves creating learning experiences that are not only developmentally appropriate but also explicitly target and strengthen specific cognitive processes (Bennett & Jamil, [2022](#); Zhang, [2024](#)).

The goal of science education is to develop a scientifically literate society, namely to support the scientific capital of all students (Archer et al., [2015](#); Glaze, [2018](#)). Previous research affirms the importance of science education (Castillo-Hernández, Jiménez-Liso, Couso, & López-Gay, [2025](#)) for fostering curiosity and environmental understanding. Nonetheless, these initiatives frequently concentrate exclusively on the natural sciences and indicate low student self-efficacy, which is ascribed to shortcomings in practical experience and theoretical foundation. This paper advocates for the expansion of science education to encompass an interdisciplinary approach. A practice-oriented methodology can expand the range of educational offerings and augment self-efficacy (Ata Aktürk & Çetin, [2024](#); Johnson, [2016](#)). Consequently, via the study of science, youngsters can cultivate their capacity to comprehend the natural events surrounding them.

Recent years have witnessed a rise in trends pertaining to science education in early childhood. The objective of science education for children is to facilitate the recognition of their environment through exploration and tangible experiences (Gelsomini et al., [2019](#); Hamel, Joo, Hong, & Burton, [2021](#)). Research conducted by Setiawan and Elnawati ([2023](#)) demonstrates that the environmental exploration strategy can markedly enhance early children's science skills. A study by Gelsomini et al., ([2019](#)) ; Jacobsen et al., ([2025](#)) corroborated that the environmental exploration strategy effectively enhances children's scientific knowledge. Exploratory science learning activities can enhance cognitive skills in early childhood (Kaliampos, [2021](#); Tairab et al., [2023](#)). Young children exhibit significant curiosity; thus, an effective educational strategy is crucial to cultivate their interest and comprehension of science from an early age. Science activities carried out should be real; children are invited to experiment, play, and explore objects that are close to their lives so that the concepts obtained are more easily understood and imprinted in the child's memory. Through simple scientific processes, children can develop basic skills such as observing, classifying, and predicting events around them.

Science learning for early childhood not only focuses on providing knowledge but also on developing scientific attitudes and critical thinking skills. Experimental methods enable youngsters to establish connections between cause and effect while fostering creativity and logical reasoning (Nafiqoh & Wulansuci, [2021](#); Wahyuni & Laksito, [2021](#)). The experiential learning technique has demonstrated efficacy in imparting significant and enduring scientific notions. In addition, science learning can also improve cognitive abilities, literacy, and children's character, such as honesty, curiosity, and responsibility. This study shows that mini practicum activities using simple materials such as baking soda and vinegar can increase children's interest and understanding of science concepts through direct experience (Yilmaz, Bekirler, & Sigirtmac, [2024](#)). This study emphasizes that exploration of the surrounding environment as a learning method provides concrete experiences that help children understand basic science concepts

more deeply (Abdullah, [2024](#)). This study found that the experimental method in science learning can improve early childhood science skills, including honesty, persistence, and exploration ability (Iqbal, Widya, Muttakin, Fuadi, & Safitri, [2024](#)). Thus, it can be concluded that science learning from an early age is an important foundation for children's future academic and social development.

Reviewing the literature on research trends in science learning in early childhood is very important as a basis for developing better educational policies and practices (AlAli & Al-Barakat, [2024](#); Sri Sukatmi & Tedy Andrian, [2024](#)). Interest in science learning in early childhood is growing, in line with the increasing awareness of the importance of introducing scientific concepts early on. Children at this age stage are in the golden age of cognitive development, where their curiosity is very high and becomes an important foundation in building logical and critical thinking. Therefore, science learning designed with the right approach can not only foster interest in science but also help children understand the world around them more meaningfully.

Research in this area is important because it can provide a more complete understanding of how young children learn and interpret science concepts. The findings from this research are expected to support teachers and educational institutions in developing learning strategies that are not only in accordance with children's developmental stages but also interesting, contextual, and applicable. In addition, this research can also reveal various obstacles faced in the field, such as limited learning resources, teacher readiness, and lack of professional training that supports the implementation of science learning at the early childhood education level. Thus, research on scientific education in early childhood is crucial, since it not only fortifies the theoretical foundation in children's education but also offers practical contributions to enhance the overall quality of learning.

Prior research indicates that early childhood science education has been examined from multiple perspectives, including pedagogical approaches, the advancement of scientific literacy, and the influence of educators and the environment. Prior research emphasized the need for employing experimental methodologies and scientifically based games to enhance children's motivation and cognitive skills. Research conducted by Suortti et al., ([2024](#)) demonstrated that the utilization of experimental approaches in scientific education can markedly enhance children's cognitive capabilities. A study by Salmawati ([2023](#)) corroborates that the experimental technique with project based learning and physical activity are closely related to stimulating cognitive abilities in early childhood education through science education. Furthermore, a study conducted by Mao, Guohui, Lu Zhang, ([2024](#)) demonstrated that the application of experimental methods in scientific education can enhance cognitive abilities in early childhood. Moreover, numerous studies have examined the cultivation of scientific attitudes and procedural abilities via science activities incorporated within the PAUD curriculum (AlAli & Al-Barakat, [2024](#); Sari Havu-Nuutinen, Kewalramani, Veresov, Pöntinen, & Kontkanen, [2022](#); Sarah, Yanti, Daryati, & Wardana, [2024](#)). These research findings provide a crucial foundation for developing engaging and successful scientific education for early childhood. Research indicates that inquiry-based approaches, particularly experimental methods and science-based games, significantly improve cognitive abilities, motivation, and scientific skills in early childhood. This effectiveness is well-documented across numerous studies, demonstrating consistent and substantial positive effects. Furthermore, integrating science activities into early childhood curricula is a critical method for cultivating foundational scientific attitudes and literacy. However, more in-depth studies are still needed regarding the latest trends and innovations in science learning in order to answer the challenges and needs of early childhood education in the modern era.

Using content analysis on several AUD journals in Scopus, from 2015 to 2025, this study aims to gain information about the dominant interdisciplinary approaches and pedagogical models used in early childhood science education over the past decade. In detail, the study was intended to answer the following questions: How does research integrate science with other domains such as literacy, arts, or moral education in early childhood? What trends can be

observed in cultural context and curriculum influences in published research on early childhood science education? What theoretical frameworks are most frequently used in early childhood science learning research? What themes are most cited and influential in early childhood science learning research between 2015 and 2025?

In several aspects, this study differs from previous studies related to early childhood science education. First, this study focused on all articles that have been published from 2015 to 2025, all of which are accredited by Scopus. Secondly, this study was devoted to investigating a number of articles with early childhood science education as the main focus. Third, various parameters were used as the basis for content analysis.

METHODS

This research employed the Systematic Literature Review approach, adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines, to identify, assess, and compile relevant scientific studies on science education methods for early childhood (Anggraeni & Listiana, [2023](#); Krisnawati, Ekawati, & Abdurachman, [2023](#); Ly, [2022](#); Rahman, Santosa, Nurtamam, Widoyo, & Rahman, [2023](#)). The following is an overview of each step in the process:

Sources of Information & Databases

The literature search was conducted across several premier academic databases, with the Scopus database serving as the primary source for the final article retrieval; the search was executed on October 23, 2025, and the results were limited to articles published in the English language.

Identify the Research Question

The primary research question guiding this systematic review is: How does contemporary research integrate science learning with other domains, such as literacy, arts, or moral education, in early childhood?

Inclusion and Exclusion Criteria

The inclusion criteria for this study are as follows: 1) Articles published in accredited scientific journals, 2) Focus on early childhood science education (aged 3-6 years), 3) Using play, multimodal, or innovative pedagogical approaches, 4) Published between 2015 and 2025, and 5) Articles available in English. While the exclusion criteria in this study are 1) non-peer-reviewed articles, 2) focus on science education at the elementary level and above, and 3) articles with irrelevant empirical data.

Sources and Search Strategies

The literature search was conducted through the scientific database Scopus, using a combination of keywords: "early childhood" AND "pedagogy" AND "science education" AND ("Early Childhood Science Education" OR "Preschool Science Learning") AND ("Pedagogical Approaches" OR "Play-Based Learning" OR "Inquiry-Based Learning") AND ("Teacher Acceptance" OR "Contextual Factors")

PRISMA 2020 Selection Process

The selection process followed the PRISMA (2020) flow in four stages: 1) Identification: 134 articles were found through the initial search, 2) Screening: from 134 articles, then filtered by year, namely 2015-2025, so that 55 articles were obtained. From the 55 articles, document type screening was then carried out and "article" was selected so that 45 articles were obtained. Then further screening was carried out on publication stage (final), source type (journal) and language (English) and the remaining 33 articles. Of the 33 articles selected open access and the remaining 18 articles, 3) Eligibility: 18 articles were read in full and analyzed, 4) Final Inclusion: 18 articles met all criteria and were used in the final synthesis. The subsequent PRISMA Figure illustrates the selection procedure.

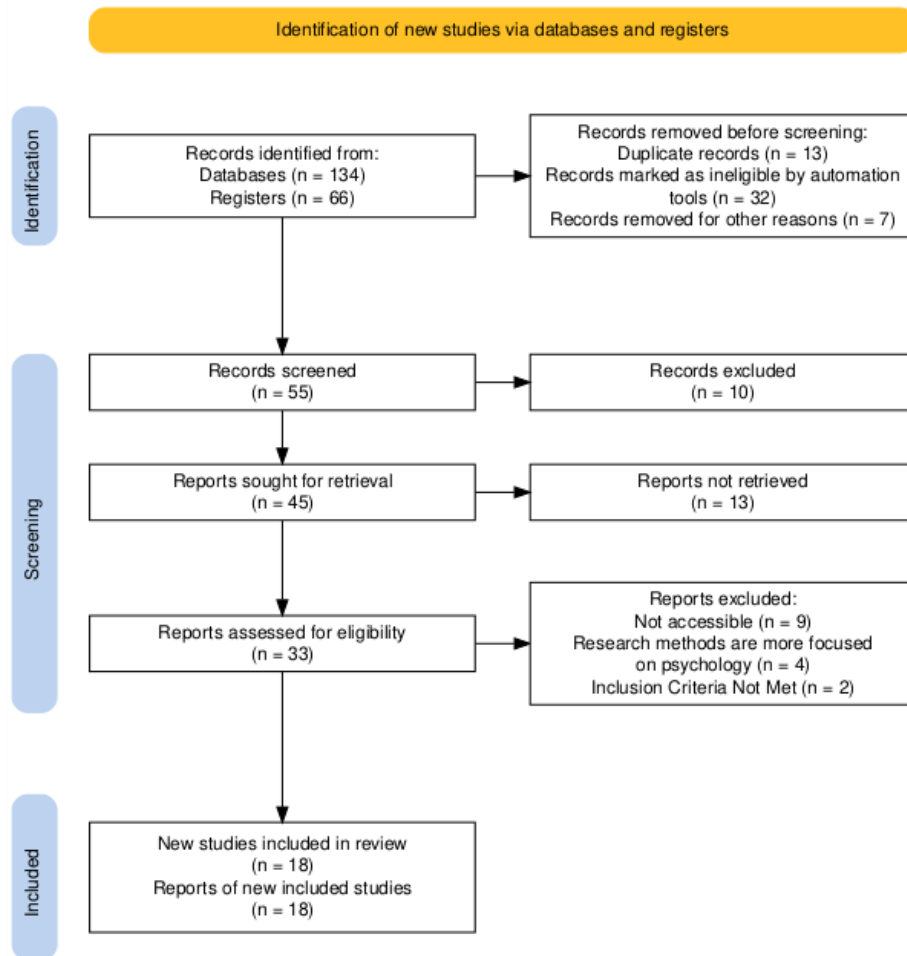


Figure 1. PRISMA 2020 Diagram

Data Extraction and Analysis

Data from each selected article was extracted into an analysis matrix, including 1) title, author, year of publication, journal, 2) Research methods and instruments, 3) Population and subjects, 4) Main findings, and 5) Thematic focus. The analysis was conducted using a thematic approach to identify patterns, gaps, and contributions from each study to the development of early childhood science education.

Literature Analysis: Trending Topics

Before proceeding to a more in-depth analysis of the 18 publications selected through the screening process, which focused on science education and learning in early childhood, the scientific software VOSviewer was utilized to visualize the relationships between keyword co-occurrences across all publications. VOSviewer (version 1.6.20) is a software tool designed to create and visualize bibliometric networks, which may include journals, researchers, or publications.

These networks are constructed based on relationships such as citation links, bibliographic coupling, co-citation, or co-authorship. Additionally, the software features text mining capabilities that enable the extraction and visualization of co-occurrence networks of key terms currently used in the scientific literature. Therefore, a bibliometric study was conducted to analyze and reveal key indicators of the dynamics and evolution of scientific information. By leveraging VOSviewer, this research focused on identifying the most relevant keywords in studies related to trends in science education for early childhood (ages 3–8), with the primary aim of understanding the main areas of expertise involved. To limit the number of clusters

formed in the VOSviewer analysis and allow for more precise analysis, a minimum co-occurrence threshold of five keywords was applied, resulting in the formation of four main clusters.

As expected, given the focused scope of the Scopus data (which was not compared to other scientific databases), the clusters formed in VOSviewer were more diverse in areas of expertise compared to clusters that were much more focused on the aviation industry, as shown in Figure 2 and Figure 3 (despite using more clusters and different inputs for both VOSviewer and the search strings in the systematic literature review).

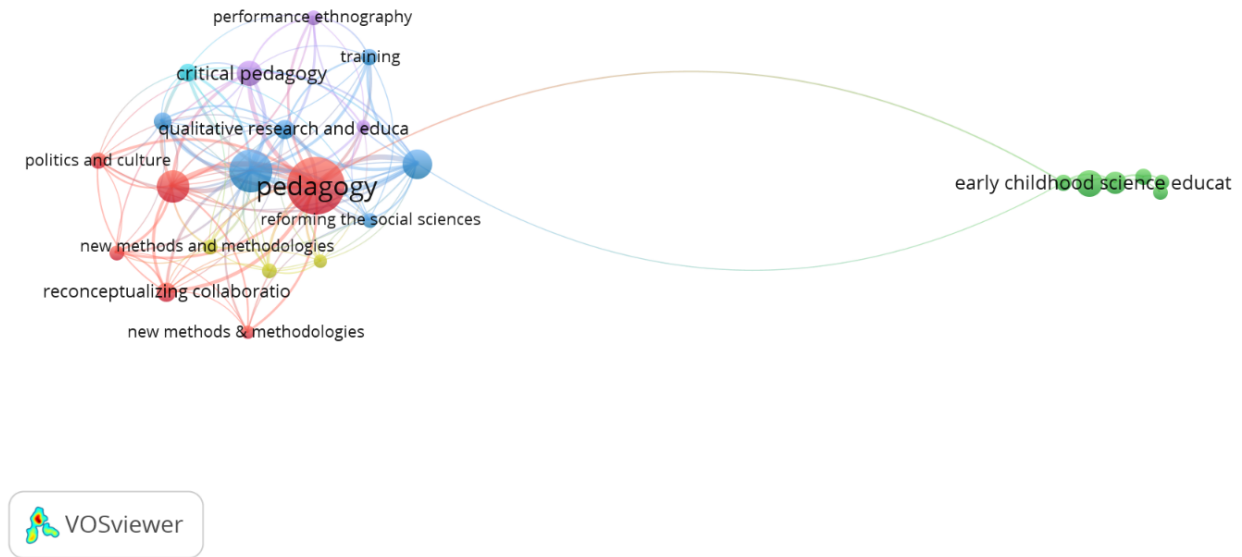


Figure 2. Network Visualization

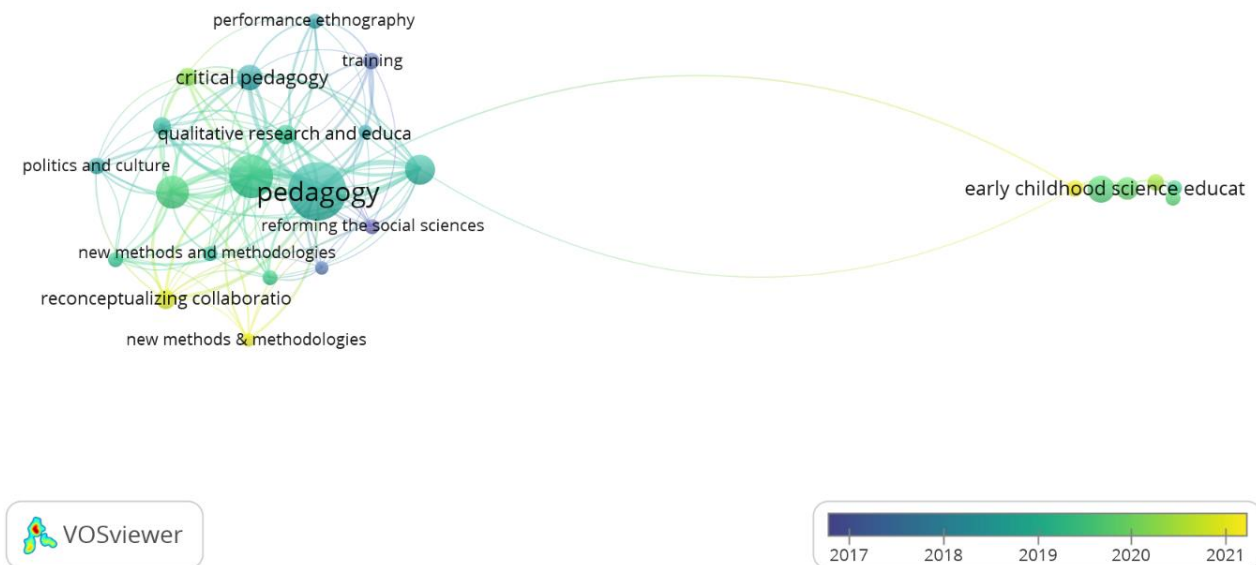


Figure 3. Overlay

For a more targeted analysis of trends in early childhood science education, Figures 2 and 3 illustrate the connections between the term “early childhood science education” and several related keywords. The visualization confirms that science education is the most frequently occurring component in publications on early childhood education for sustainability. This pattern is indicated by the strong links between “early childhood science education” and related terms such as early childhood education, early childhood learning, pedagogy, science, science education, and young children. These keyword connections show that recent studies tend to

position early childhood science education within a broader pedagogical framework that emphasizes children's learning experiences, scientific exploration, and developmentally appropriate instructional practices.

However, it is also important to note that Figure 2 reveals several less frequent keywords associated with early childhood science education, such as "inquiry," "role play," and other operational terms like "cognitive," "puppets," and "methodology." This analysis offers a slightly broader and more nuanced perspective than Ly and McKenzie (Akl et al., [2024](#); Ly, [2022](#)), likely due to the influence of the search strings used, which were more focused on early childhood science education. Nevertheless, the main recommendations remain consistent. The bibliometric analysis also highlights the need for further research encompassing additional aspects of early childhood science education (Anggraeni & Listiana, [2023](#); Clough & Nutbrown, [2019](#)).

The Define stage identifies the learning needs and the specific challenges students face in developing critical thinking skills related to Thermodynamics. This stage involves gathering data on student difficulties and areas where critical thinking can be integrated into learning materials. In the Design stage, the initial version of the AR-based E-LKPD is developed, along with the research instruments required for validation and data collection. The design process also involves creating a structure that aligns with the LOK-R model, ensuring that students can engage with both the content and the technology. The integration of AR into the learning process is based on research by Martín-Gutiérrez et al. ([2017](#)), which emphasizes the potential of AR to improve learning outcomes in complex subjects like physics. In the Develop stage, the final product is produced through expert validation from material and media specialists, followed by limited trials with students to assess its effectiveness.

To evaluate the developed product, a combination of test and non-test instruments are employed. The test instruments consist of pretest and posttest assessments, measuring students' critical thinking skills through essay questions on Thermodynamics. The non-test instruments include validation sheets completed by subject matter experts and media experts, as well as questionnaires to gather feedback from students and educators on the usability and effectiveness of the E-LKPD. All instruments are carefully validated to ensure the accuracy and relevance of the data collected. Data analysis is performed by calculating the average validation score, the percentage of positive responses from questionnaires, and the N-gain score, which reflects the improvement in students' critical thinking skills between pretest and posttest (Nurdin & Hartati, [2019](#)). This method of evaluation is aligned with the approach used by Ramasamy et al. ([2019](#)), who applied similar data analysis techniques to assess the effectiveness of educational technologies in improving student outcomes.

RESULT AND DISCUSSION

How research integrates science with other domains such as literacy, arts, or moral education in early childhood, and what observable trends in cultural context and curriculum influence in published research on In early childhood science education, what theoretical frameworks are widely used for research, and what themes are most commonly referenced and impactful in early childhood science learning research between 2015-2025. Based on the Scopus online database, 7 articles were found that met the inclusion criteria for further analysis. The 7 articles that discuss science in early childhood are shown in Table 1.

Table 1. Early Childhood Science Article

No	Article Title	Research Objectiveness	Methodology	Main Findings	Educational Implications
1	Dramatic Play as a Means (Fragkiadaki,	Exploring the role of role play in shaping the concept of thermal	Qualitative - observations, children's drawings, teacher notes	Children build understanding of thermal insulation	Role play can be used as a pedagogical

No	Article Title	Research Objectives	Methodology	Main Findings	Educational Implications
2	Armeni, Zioga, & Ravanis, 2021) Exploring Relationships Between Playspaces, Pedagogy, and Science Practices (Miller & Saenz, 2021)	insulation in early childhood Examines the relationship between play spaces, teacher strategies, and children's science practices	Observations using the SciEPOP (Science and Engineering Practices Observation Protocol)	through narratives and experiences Children engage in NGSS practices when given appropriate space and pedagogical support	approach to develop science concepts The environment and the role of the teacher are critical to children's scientific engagement
3	Dialogic Pedagogies and Multimodal Methodologies (Siry, 2020)	Examining dialogic and multimodal pedagogical approaches to inclusion in science education	A case study in a multilingual context	Dialogic approaches strengthen children's agency in conveying scientific understanding	Multimodality and dialog expand access to equitable science learning
4	If You Can Program You Can Write (R Hassenfeld, Govind, E De Ruiter, & Umashi Bers, 2020)	Examine the relationship between literacy skills and programming mastery	Quantitative - PALS correlation & programming assessment	Positive correlation between literacy and programming skills; CAL effective for children with low literacy	Programming can be integrated into literacy to support thinking skills
5	Preschool Children's Conceptions of Water, Molecule, and Chemistry (Åkerblom, Součková, & Pramling, 2019)	Analyzed 6-year-olds' understanding of chemistry concepts before and after dramatic intervention	Pre-post interview & observation of theater activities	Children move from everyday understanding to more abstract understanding after intervention	Educational drama is effective for introducing abstract science concepts
6	Teaching for Emergent Disciplinary Drawing (Areljung, Skoog, & Sundberg, 2022)	Examines how teachers and children use drawing to represent science content	Observation of 11 lessons & analysis of 129 children's drawings	Children adapt their drawing style to the examples given by the teacher	Teachers need to provide rich semiotic resources for scientific drawing
7	Why Do Teachers Adopt or Resist a Pedagogical Idea (Areljung, 2019)	Explain why teachers accept or reject pedagogical ideas in science learning	Teacher interviews	Teachers accept approaches that fit with daily practices & ECE values	PD should be relevant, applicable and support teacher autonomy
8	Developing a research instrument to record pre-school teachers' beliefs about teaching practices in natural sciences (Draganoudi, Kaliampos, Lavidas, & Ravanis, 2023)	Developed and validated a 21-item instrument to assess pre-school teachers' beliefs about natural science teaching practices, categorized into four pedagogical approaches.	The systematic analysis of curricula	Pre-school teachers mainly adopt practices fitting the empiricist approach	The 21-item instrument can measure pre-school teachers' beliefs about physical sciences practices with validity, useful for studies with limited survey time and cross-cultural comparisons Incorporate more activities addressing food classification, observation, and taste-testing & Dedicate more teacher effort to plant growth monitoring and data recording
9	Development of Food Competence in Early Childhood Education (López-Banet, Miguélez Rosique, Martínez-Carmona, & Ayuso Fernández, 2022)	Implemented an instructional sequence in early childhood education to develop food competence and scientific skills by focusing on plant observation, germination, and growth.	The experimental group	The activities motivated children, fostering early interest in science and food competence	
10	Powering Up Preschool Science: A Home-School-Community Partnership to	Evaluated the SISTEM program, a home-school-community partnership aimed at boosting science	Mixed-methods approach	Educators in the treatment group gained confidence in supporting science with emergent	Educators gained self-efficacy in science teaching, especially for EMLs & Shifts in teaching

No	Article Title	Research Objectives	Methodology	Main Findings	Educational Implications
11	Support Science Learning with a Focus on Emergent Multilingual Learners (Young, Hoisington, Kook, & Ramer, 2024)	learning for young emergent multilingual learners (EMLs)		multilingual learners (EMLs) and showed significant increases in instructional quality compared to control classrooms	practice promoted children's scientific inquiry
	The influence of emotions on science teaching: a case study with three early childhood education teachers (Praderio Gaias, Furman, Luzuriaga, Borrego, & Ayuso Fernández, 2024)	Explores how early childhood education teachers' emotions influence their science teaching practices.	Qualitative design employing a multiple case study approach	Negative emotions from past experiences reduce engagement, while positive emotions enhance motivation and enrich the learning environment	Teacher training and professional development programs should incorporate understanding and managing negative emotions to enhance teacher confidence and satisfaction in early childhood science education
12	Science Concept Formation During Infancy, Toddlerhood, and Early Childhood: Developing a Scientific Motive Over Time (Fragkiadaki, Fleer, & Rai, 2023)	This study investigated how children develop a science motive from infancy through early childhood, finding it emerges when play and science learning interrelate.	Longitudinal study following a cultural-historical approach	The study found that children develop a science motive throughout infancy, toddlerhood, and early childhood, with teachers playing a crucial role in creating motivating conditions for this development, which is not a linear progression	Science motive develops when play and learning motives are dialectically interrelated over time
13	Young children's translanguaging as emergent in and through open-ended science pedagogies (Siry, Wilmes, & Sportelli, 2025)	The study explores how young plurilingual children engage in science investigations, particularly focusing on their interactions while exploring worms. It highlights the importance of open-ended pedagogical structures in supporting communication and learning in a multilingual context, specifically in Luxembourg's trilingual schools	The study employs multimodal interaction analysis to examine the interactions of plurilingual children and their teacher during science investigations, focusing on their communication and engagement in open-ended pedagogical structures	The study reveals that young plurilingual children effectively utilized translanguaging during science investigations, enhancing their communication and engagement in learning about worms and vermicomposting.	The study highlights the importance of creating equitable learning environments where teachers and students honor the richness of children's communication repertoires, thereby fostering inclusion and equity in science learning spaces
14	Early Childhood Special Science Education: setting the frame of a newly born and well-promising trend (Kaliarnos, 2021)	Explores how young plurilingual children engage in science investigations, particularly focusing on their interactions while exploring worms.	The paper employs a literature review methodology to provide an organized overview of Early Childhood Science Education	The paper's main finding is the identification and framing of a new, promising trend called Early Childhood Special Science Education	Teachers should use attention-focusing, highly structured, and guided questions to help disabled pupils concentrate and maintain systematic thinking
15	Preschool Teachers' Preparation Programs: The Use of Puppetry for Early Childhood Science Education (Ocal, Karademir,	Explored how puppetry can enhance early childhood science education standards.	Employe an explanatory sequential mixed methode design	The puppet-making and puppetry workshop moderately increased preservice teachers' total and personal science	Puppetry can improve early childhood science education standards by helping preservice teachers develop positive

No	Article Title	Research Objectives	Methodology	Main Findings	Educational Implications
16	Saatcioglu, & Demirel, (2021) Understanding Early Childhood Science Education: Comparative Analysis of Australian and Finnish Curricula (Sari Havu-Nuutinen et al., 2022)	Compares early childhood science curricula in Finland and Australia, finding both incorporate constructivist elements but differ in science education focus.	Employed a comparative curricula analysis using the analytic document analysis method	teaching efficacy beliefs Both Australian and Finnish EC curricula contain constructivist components, but science education is not always clearly focused	attitudes towards science and offer engaging activities Provide early childhood educators with tangible and theoretically solid curriculum frameworks and resources to foster scientific thinking in young children Support pedagogical content knowledge of EC teachers in science through education and professional development programs & Policymakers should consider ESET as an explicit aspect of early childhood education, emphasizing socio-emotional aspects
17	Early science education for toddlers (1-3-year-olds) in natural environments – exploring the perspectives of early childhood teachers in Norway (Jacobsen et al., 2025)	Explores Norwegian early childhood teachers' perspectives on early science education for toddlers (1-3 years old) in natural environments.	The study employed semi-structured interviews with eight EC teachers from seven ECEC institutions in Norway	ESET in natural environments is characterized by informal activities deeply integrated with socio-emotional aspects	
18	A material for education process and the Teacher: the use of digital storytelling in preschool science education (Yilmaz & Siğırtmaç, 2023)	Investigate the pre-service teachers' opinions and experiences about the process including the selection of the science concepts, preparation, and implementation of the digital story by focusing on the use of digital stories in pre-school science activities.	Multiple holistic case design	The advantages of using digital stories in pre-school science activities, the dimensions that need to be improved, limitations of using digital stories, and digital literacy.	Incorporating technology in general and digital stories in particular into teacher training programs.

Data extraction and Analysis Overall, the seven studies support the importance of play-based pedagogy, multimodality and experiential approaches in early childhood science education. Interventions that incorporated drama, literacy and visualization showed improvements in children's conceptual understanding and provided new insights into how teachers can design effective and inclusive science learning in preschool settings. The dominant approach types in all seven articles were role-playing, multimodality, contextualized learning. Context: Early childhood education, elementary science, programming, and visual representation. Collective contribution: All seven studies showed that experiential, inclusive and integrated approaches are more effective in fostering understanding of scientific concepts in early childhood. Data from each selected article was extracted into an analysis matrix, including:

- 1) Title, author, year of publication, journal.
1. Role play, multimodality and curriculum integration. Based on the seven articles, the pedagogical approach used in early childhood science learning centers on the integration of play, multimodality and cross-curricular connections. Dramatic play was used to bridge abstract concepts such as thermal insulation and molecules (Åkerblom et al., 2019; Fragkiadaki et al., 2021). Multimodality through images, movement and dialog is used to enable children to express their science understanding in different ways, especially in multilingual and culturally diverse contexts (Areljung, 2019; Siry, 2020). Besides that, the

puppet-making and puppetry workshop moderately increased preservice teachers' total and personal science teaching efficacy beliefs (Ocal et al., [2021](#)). Integration across domains such as programming and literacy (Hassenfeld et al.) shows that the development of cognitive abilities does not have to be limited to one domain.

2. The role of environment and teacher in facilitating learning. Almost all studies emphasize the importance of the teacher's active role and the design of the learning environment in supporting children's engagement. The study by Miller & Saenz showed that play spaces rich with science materials and teacher pedagogical interventions enabled deep engagement in scientific practices based on the NGSS framework. Teachers who are able to identify and respond to children's ideas enable more constructive and participatory learning (Areljung, [2019](#); Siry, [2020](#)). Dialogic and multimodal approaches enhance children's agency, inclusion, and communication in science, especially in multilingual settings. Teachers' openness to new pedagogical ideas is influenced by alignment with daily practice and values. The role of dialogic, multimodal, and translanguaging strategies in fostering equitable and inclusive science learning (S Havu-Nuutinen, Kewalramani, Veresov, Pöntinen, & Kontkanen, [2021](#); Kaliaspos, [2021](#); Siry et al., [2025](#)). The implication is that teacher training needs to focus not only on content knowledge, but also on sensitivity to children's learning processes and selection of flexible pedagogical strategies.
3. Transformation of scientific concepts through an experiential approach. Several studies show how children can form more abstract scientific understandings through concrete experiences. Children move from "everyday" understandings to more abstract concepts such as the insulating properties of materials or the molecular structure of water following drama-based interventions (Fragkiadaki et al.; Åkerblom et al.). This transition process is strongly influenced by reflective activities such as drawing, dialoguing and re-presenting their findings. Support pedagogical content knowledge of EC teachers in science through education and professional development programs & Policymakers should consider ESET as an explicit aspect of early childhood education, emphasizing socio-emotional aspects (Jacobsen et al., [2025](#)) Thus, play and visualization activities support children's cognitive developmental stages in understanding complex scientific concepts.
4. Teacher resistance and adoption of new approaches. In Areljung's ([2019](#)) study, teachers were more likely to adopt approaches that were relevant to daily practice and in line with the values of ECE pedagogy, compared to experimental approaches that were separate from daily routines (Praderio Gaias et al., [2024](#); Siry et al., [2025](#); Suortti et al., [2024](#); Yilmaz & Siğirtmaç, [2023](#)). Teachers adopted the pedagogical approach because of the ease of integration into daily activities and because it supported their need for a flexible, interactive and non-academic pedagogy. Another key factor was long-term professional support and collaboration with researchers rather than one-way training.
5. Visual representations in shaping science literacy. The use of images as representations of scientific concepts received special attention in the study by Areljung et al. ([2022](#)). Teachers play an important role in shaping children's understanding of "how to draw in the context of science", including children's tendency to reduce decorative elements and increase visual precision. The paper's main finding is the identification and framing of a new, promising trend called Early Childhood Special Science Education (Kaliaspos, [2021](#)). Children actively adjust their visual representations based on semiotic sources and feedback from teachers and classmates. This suggests that science visual literacy should be introduced systematically and not just as a product of free expression.

A systematic analysis of the seven articles concludes that the most effective approaches to science learning in early childhood education are contextual and experiential, including dramatic play, free exploration, and visualization. Facilitated by enriched learning environments and reflective teaching strategies, with educators actively guiding and responding to students' cognitive processes. Incorporated with various disciplines such as literacy, technology, and the arts to promote interdisciplinary thinking. Develops scientific comprehension progressively,

transitioning from tangible experiences to abstract representations and generalizations. Customized for educator practice and based on collaboration and professionalism in curriculum development.

This study provides a strong foundation for the development of an inclusive, holistic, play-based early childhood science curriculum. Relevant articles and core findings

1. Playful Approaches to Science Learning, authored by Fragkiadaki et al. (2021); Åkerblom et al. (2019) related to Dramatic Play as a medium for exploring scientific concepts concluded that Role play helps children understand abstract concepts such as thermal insulation and molecules through narratives and simulations of everyday experiences and the article written by Miller & Saenz (2021) related to Free play and space exploration concluded that Children actively use scientific practices in free play, especially if supported by adaptive teacher environments and strategies (Ocal et al., 2021; Yilmaz et al., 2024). This playful approach helps them grasp tricky, abstract ideas by connecting them to their own lives and imaginations. The key is that teachers need to be involved, not to take over, but to gently guide and set up an environment that encourages this kind of deep exploration.
2. Multimodality and Visual Representation, written by Siry (2020) related to Multimodality in scientific communication concluded that Children show scientific understanding through body language, gestures, drawings, and oral expressions; dialogic opens space for inclusion. While the article written by areljung et al. (2022) related to Drawing as a means of representing science concepts concluded that Teachers influence the way children draw science; children adapt their drawings to contextual expectations and semiotic resources in the classroom.
3. Integration of Curriculum and Disciplines, written by Hassenfeld et al. (2020) related to programming as a form of literacy, there is a positive correlation between literacy and programming skills and integrative approaches encourage the simultaneous development of the two competencies (Kaliampos, 2021; Praderio Gaias et al., 2024; Suortti et al., 2024). In addition, activities that integrate stories, art, or literacy support cross-disciplinary understanding and enhance. Research indicates a positive correlation between literacy and programming skills, demonstrating that integrative, cross-disciplinary activities simultaneously advance both competencies and deepen overall understanding.
4. The Role of Teachers and Pedagogical Strategies, concluded by (Miller & Saenz, 2021); (Areljung, 2022) related to teacher strategies in supporting scientific practices in the form of teacher strategies such as open-ended questions, scaffolding, and visual feedback greatly influence the way children engage and express understanding. In addition, Areljung's (2019) adoption of and resistance to new approaches is that teachers are more likely to adopt approaches that can be integrated into daily practice than separate experimental approaches (Young et al., 2024). Consequently, effective science instruction utilizes practical strategies like scaffolding and open-ended questions, which are most impactful when authentically embedded into teachers' daily practices rather than employed as distinct, experimental add ons.
5. Early Childhood Conceptual Development, summarized by (Åkerblom et al, 2019); (Fragkiadaki et al, 2021) is related to the Transition from everyday understanding to scientific concepts (Draganoudi et al., 2023; Jacobsen et al., 2025; Suortti et al., 2024). Children begin to build abstract concepts (e.g. molecules, isolation) through play activities mediated by reflection, drawings, and discussion. (Areljung et al, 2022); (Siry, 2020) Concluded that Emergent disciplinary literacy Children begin to form early "science literacy" which is evident from the ability to describe, explain, and discuss scientific phenomena.

Bar chart showing the distribution of articles by publication year. It can be seen that the articles are evenly distributed between 2019, 2020, 2024, dan 2025 (2 articles each), and three article was published ini 2022-2023, as well as four article was published in 2021 is below.

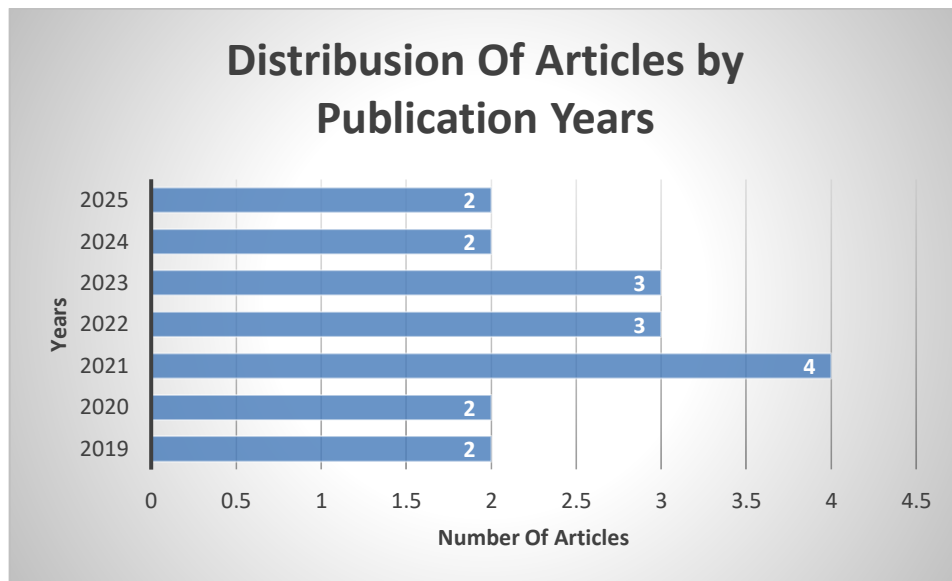


Figure 3. Article Distribution Diagram

Figure 3 illustrates the distribution of the number of articles by publication year. The horizontal axis (x) shows the number of articles published. While the vertical axis (y) represents the year of publication, namely articles published in 2019, 2020, 2021, 2022, 2023, 2024 and 2025.

Limitation and Future Trend

A number of limitations must be noted in this investigation. First off, the review was limited to seven Scopus-indexed articles from 2015 to 2025, which might not adequately represent the range of research in early childhood scientific education conducted in various languages and contexts. Second, the study might have overlooked pertinent studies carried out in non-English or local contexts because it was based on published English-language literature. Furthermore, most of the reviewed studies employed small-scale case studies, qualitative approaches, or context-specific interventions, which limit the generalizability of findings. Despite these constraints, the review highlights promising future directions, including the need for longitudinal and cross-cultural studies to better understand how children's science concepts develop over time, the integration of emerging technologies such as digital simulations and AI-based learning tools into play-based science education, and professional development models that strengthen teachers' capacity to adopt multimodal, experiential, and interdisciplinary pedagogical approaches. The ways in which curriculum and policy changes might promote fair access to worthwhile science education for all young children should also be the focus of future studies.

In 2019 and 2020, 2 articles were published. In 2021, the number of published articles increased to 4. Meanwhile, in 2022 and 2023, there was a decrease in the number of published articles compared to 2021, namely 3 articles published. In 2024 and 2025, there was another decrease, each time to 2 articles. During the period 2019 to 2020, the number of articles published each year was relatively stable at two articles. However, in 2021, there was a significant increase, meaning that in that year there were quite a lot of articles discussing science education in early childhood. However, from 2022 to 2025 there was a gradual decline, the number of published articles decreased again to 2 articles. This may reflect research or publication trends that may be influenced by factors such as changing research priorities, resource availability, or other external factors.

CONCLUSION

Based on a systematic review of eighteen Scopus-accredited scientific articles (2015-2025), this study found that research trends in early childhood science learning emphasize the importance of concrete experience-based approaches, multimodality and integration across the curriculum. Role-playing methods, simple experiments and visual representations have proven effective in helping young children understand abstract science concepts. Science learning designed through drama, environmental exploration and creative activities promotes children's transition from everyday to more conceptual scientific understanding. The role of the teacher and learning environment is significant in supporting children's engagement in scientific practices. Teachers who are able to provide rich play spaces, appropriate scaffolding and visual feedback help children more actively participate and explore science in a developmentally appropriate way. Research also shows that teachers' adoption of new approaches is more likely to be successful when they are relevant to the daily practices and pedagogical values already internalized in the Early Childhood Education Programs.

Furthermore, interdisciplinary integration involving literacy, technology, and the arts fosters the development of several, mutually reinforcing competences, such as critical thinking, creativity, and scientific literacy. The study indicated that instructors resist methods deemed inappropriate to their daily circumstances; thus, teacher training must be contextualized, applicable, and promote professional teamwork. This work significantly contributes to the advancement of a more inclusive, comprehensive, and play-oriented early childhood science curriculum. These findings are anticipated to provide a foundation for educators, policymakers, and researchers to further create science learning methodologies that align with child development needs and contemporary demands.

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