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A Systematic Review of Scientific Literacy in Early Childhood Science Learning: Approaches, Methods, and Media

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Abstract: Building scientific literacy from an early age is essential for developing critical thinking skills, problem-solving abilities, and a basic understanding of scientific concepts. This article presents a systematic review of science learning strategies for young children, highlighting effective approaches, methods, and media. The study analyzes literature from various scholarly sources within a specific timeframe. The findings indicate that inquiry-based approaches, such as water and ice experiments to understand phase changes, as well as play-based and environmental exploration approaches, such as observing insects in a garden, are effective in enhancing young children's scientific literacy. Simple experimental methods, such as creating a volcanic eruption using baking soda and vinegar, and STEM-based projects help children grasp scientific concepts concretely. Learning media, including natural teaching aids (leaves and rocks for classification), interactive digital applications, and augmented reality-based educational games, have been proven to increase children's engagement. The implications of this study emphasize the importance of integrating hands-on experiences and technology in early childhood science education to create enjoyable and meaningful learning experiences. This article serves as a reference for educators and researchers in designing innovative and effective science learning strategies.

Keywords: Approaches; Early childhood; Learning media; Methods; Science learning; Scientific literacy

Introduction

Science education in early childhood is an important foundation in building critical thinking skills, creativity and science literacy that will help them understand the world around them (Westhisi et al., 2019). Science literacy, which includes an understanding of basic science concepts, the ability to think scientifically, as well as the application of science knowledge in everyday life, is one of the key skills of the 21st century (Aydin-Ceran, 2021; Ellizah et al., 2020). Science as a collection of knowledge, processes, and values can be used as a basis for implementing science learning in the classroom. Learners not only learn about science products, but also experience the process of learning through science based on the principles of the nature of science. Early introduction of science literacy can shape children's interest in science, which contributes to the development of a scientific mindset in the future (Mateeva et al., 2022).

In the context of early childhood education, learning approaches, methods and media are the main factors that influence the success of science literacy development (Dibyantini et al., 2023; Sriwarthini et al., 2023). Approaches such as inquiry, exploration and play have been widely applied to encourage children's active involvement in science learning (Counsell, 2022). For example, the inquiry approach allows children to ask questions and conduct simple investigations to find answers, while environmental exploration allows them to observe phenomena directly. Science-based play, such as experiments with liquid and solid objects or magnet

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play, provides a fun and meaningful learning experience (Habibi, 2023).

Effective science learning can improve learners' critical thinking skills, scientific attitudes and science literacy. The Discovery Learning model is proven to have a positive influence on students' critical thinking skills and scientific attitudes because it encourages them to actively explore and discover concepts themselves (Nursakinah & Suyanta, 2023). In addition, the Guided Inquiry model is also effective in improving scientific reasoning because it provides guidance in the investigation process so that students can develop a deeper understanding (Yulianti & Zhafirah, 2020). Meanwhile, Nature of Science-based learning that utilizes learning resources from digital platforms such as Rumah Belajar Kemdikbud can improve students' science literacy by providing a more contextual and interactive learning experience (Lestari et al., 2020). Thus, active, exploration-based and technology-supported learning approaches are essential in improving students' understanding of science.

These methods rely on activities that encourage children to observe, ask questions, experiment and find answers independently. Meanwhile, innovative learning media, both in the form of natural props such as rocks, water and plants, as well as digital technology such as interactive simulations and educational applications, play an important role in making learning more interesting and relevant to children (Candra et al., 2025).

However, while much research has been conducted on science literacy and science learning for early childhood, there is still a gap in understanding how approaches, methods and media can be effectively integrated for optimal learning outcomes (Yulianti & Zhafirah, 2020). Most studies focus on only one aspect, such as the effectiveness of inquiry methods or the impact of digital media on children's engagement, but not many have comprehensively examined the integration of the three elements. Therefore, a more thorough study is needed to understand how a combination of approaches, methods and media can improve science literacy more effectively (Zamzam et al., 2023).

This systematic review aims to identify, analyze and synthesize current findings on science literacy development in early childhood science learning (Matahari et al., 2023). The article will discuss the contribution of different approaches, methods and media to the achievement of science literacy and offer recommendations for the development of better science education practices. This review is expected to provide insights for educators, practitioners and researchers in designing innovative and effective science learning strategies for early childhood. Thus, science literacy can become an integral part of the early years education curriculum, equipping children with scientific skills that are relevant in the modern era.

Method

Research Design

This research applies the Systematic Literature Review (SLR) method by utilizing Vosviewer software to visualize the findings obtained. This research provides descriptions, reviews, and analysis related to science learning in terms of approaches, methods and media conducted in early childhood. In the process, the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) approach is used to identify, screen, evaluate feasibility, collect data, analyze, and present results narratively.

Selection of Inclusion and Exclusion Criteria for Publication

The five criteria applied in the inclusion and exclusion stage are as follows: The selected articles have been indexed in Scopus and Google Scholar; The articles searched discuss science learning in early childhood; The literature search in the Scopus database was carried out using the Publish or Perish 7 program by entering the API key, and additional searches were carried out through the ScienceDirect database; The reviewed literature consists of scientific articles and conference proceedings; The range of years of publication of the articles is limited between 2018 and 2023.

Screening and Feasibility Assessment for Data Analysis and PRISMA Flowchart

The screening process was based on titles, keywords, and abstracts relevant to the theme of science learning in early childhood. From the search results, 193 research articles published in the last six years (2018-2023) were obtained. The keywords used in the search through the Scopus and ScienceDirect databases are listed in Table 1. Of the 193 articles found, further selection was carried out using the PRISMA technique. All articles were exported to Excel to identify duplication, and 15 articles were eliminated due to duplication. Next, articles relevant to science learning were further reviewed, resulting in 178 articles. Further screening was done to select articles that specifically addressed approaches, methods and media in early childhood science learning, leaving 65 articles.

The final selection stage considered the open access of the articles. A total of 9 articles were not freely available, so only 56 articles will be reviewed further in this study. Table 1 shows the quantity distribution of keywords related to research in science education. The first keyword, “Science Media,” appeared 48 times sourced from PoP 7. The second keyword, “Science

Learning Approach," was recorded 60 times without listing a specific source. The third keyword, "Science Learning Methods," was recorded 45 times. Finally, "Science for Early Childhood" was found 40 times with sources from the Science Direct Database. Overall, the total number of keywords recorded in this table is 193, reflecting a broad research focus in various aspects of science learning and media.

Table 1. Keyword distribution of science education research

Keyword	Quantity	Source
Science Media	48	PoP 7
Science Learning Approach	60	Scopus
Science Learning Methods	45	Scopus
Science for Early Childhood	40	Science Direct Database
Total	193	

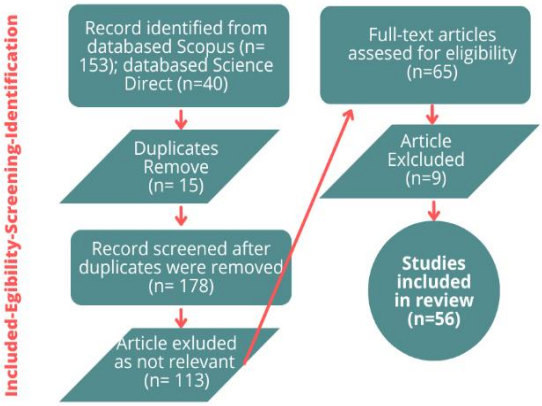

Figure 1. Canva flow diagram

The 56 articles selected for this study were entered into the Mendeley program, then exported in RIS format for bibliometric analysis using Vosviewer version 1.6.17. Vosviewer is a software developed by Van Eck and Waltman from Leiden University, the Netherlands, designed to build and visualize bibliometric networks. The software can be used to map relationships between journals, researchers, keywords, and publications based on links in co-citation, clustering, and co-authorship (Kurniawan et al., 2024). Data downloaded from Scopus was used in the creation of the RIS file.

After going through a four-stage systematic review process, the RIS file was updated by removing articles that were not relevant to this study. Next, the RIS file was entered into Vosviewer to generate co-occurrence maps from the bibliographic data. This software allows visualization of maps based on various aspects, such as keywords, number of journal citations, and publication titles (Van Eck & Waltman, 2022). Bibliometric analysis was conducted on each article by considering aspects such as year of publication, keywords, number of citations, and country of origin.

Result and Discussion

PRISMA-P

An initial database search identified 193 articles related to Science Learning. The literature was then filtered for the period 2018-2023. The literature was filtered by article type, including only journal or review articles, as well as articles published in English. This filtering reduced the number of articles identified to 178. The screened articles were then downloaded from relevant databases and checked for duplication. After screening duplications and 113 were removed as they were not directly related to this study. Abstracts of the remaining 65 articles were reviewed. The full texts of the 65 articles were then further reviewed, with 9 articles. Thus, a total of 56 journal articles were used in this systematic review.

This section presents the research results obtained from data analysis as well as a discussion that links the findings with theory and previous research. The results of this study reveal patterns, trends, and relationships between the variables studied, which are then analyzed in depth to understand their implications in the context of early childhood science learning. In addition, the discussion will explore how these findings support or differ from previous studies, as well as practical implications that can be applied in the development of learning methods, media and approaches.

Bibliometric Analysis

Journals and Citations

Science learning is widely used in various disciplines, as revealed by 56 articles relevant to this study. The relevant articles come from several journal. The titles of the most highly cited articles are shown in the Table 2.

Author Affiliated Countries

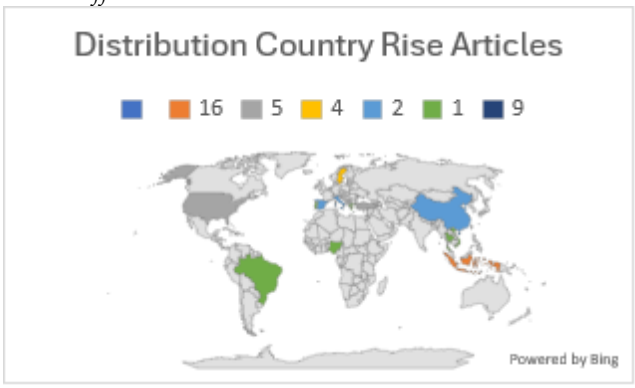

Figure 2. Distribution country rise articles

Figure 2 presents the distribution of countries that published educational research on early childhood science learning. There are 17 countries that discuss the use of media, methods and approaches. The colors on the map indicate the number of articles published by a country. The country that contributes the most is marked in dark blue, Indonesia, which represents 16 articles. Countries with medium contributions, such as 9 articles, are colored green, i.e. research conducted in several countries. The other colors, such as orange, yellow, and gray, indicate countries with a lower number of articles, which are 5, 4, 2, and 1 article, respectively, coming from America, Turkey, Spain, and some other countries in Europe.

This map illustrates that article contributions are unevenly distributed around the world. Some countries, as marked in dark blue, stand out as major contributors, while others have smaller contributions. This gives an idea of the geographical distribution of article publications globally.

Table 2. Journal articles with top citations

Rating	Article Title	Authors	Journal Title	Year	Citation
1	The Effect of STEM (Science, Technology, Engineering, and Mathematics) Based Learning Approach on Critical Thinking Skills and Cognitive Learning	Minarti et al.	At-Tasyrih: Jurnal Pendidikan …	2022	61
2	Storytelling in early childhood education: Time to go digital	Rahiem	International Journal of Child Care and Education Policy	2021	41
3	Approaches to learning and science education in Head Start: Examining bidirectionality	Bustamante et al.	Early Childhood Research Quarterly	2018	40
4	Development of preschool children's executive functions throughout a play-based learning approach that embeds science concepts	Carulla et al.	International journal of …	2021	35
5	Pre-service early childhood teachers' views on STEM education and their STEM teaching practices	Çiftçi	Research in Science and Technological Education	2022	31

Distribution Year Rise Articles

The Figure 3 shows the distribution of the number of articles by year from 2018 to 2024. The bar graph shows a significant increase in the number of articles over this period. In 2018 and 2019, the number of articles is still low, with less than 4 articles each year. This number increased quite sharply in 2020 and continued to stay at a high level until it peaked in 2023 with 14 articles. However, in 2024, there was a significant drop compared to the previous year. This graph reflects the increasing trend in the number of articles published until 2023, followed by a decrease in 2024.

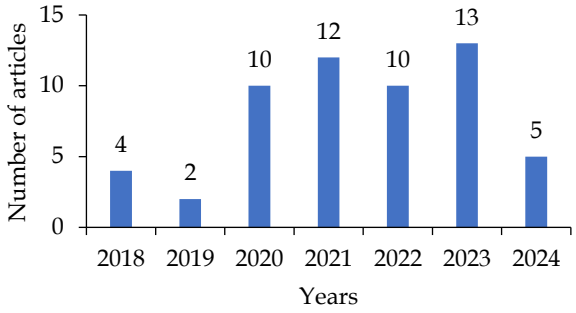

Figure 3. Distribution year rise articles

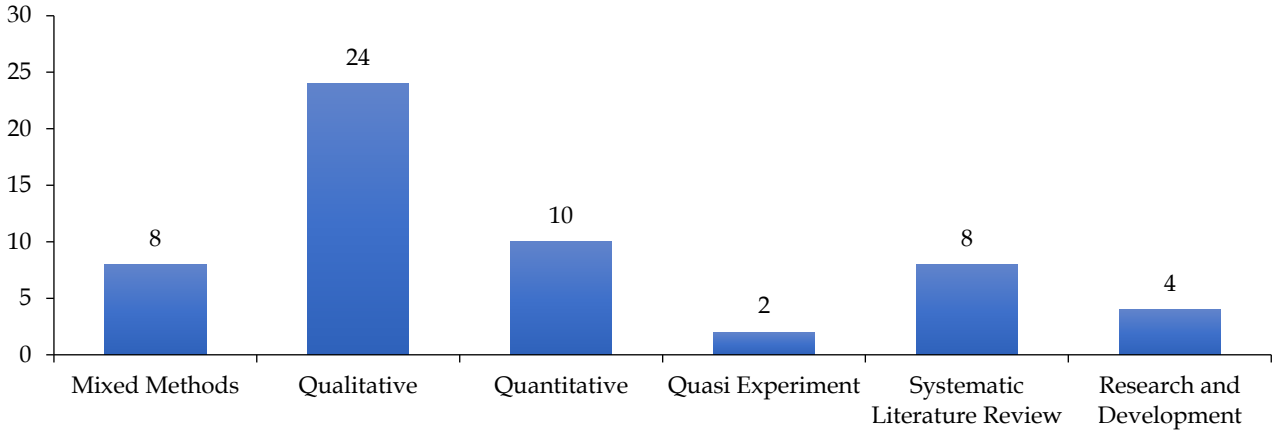

Figure 4. Research methods

Figure 4 is a bar chart showing the distribution of research method use. The most widely used research method is qualitative method, with a total of 24 studies. Quantitative methods ranked second with 10 studies, followed by mixed methods and systematic methods, each with 8 studies. Quasi-experimental methods were used in 2 studies, while the research and development (R&D) category recorded 4 studies.

This diagram shows that qualitative methods dominated the research, indicating the preference or suitability of these methods to the field of study under study. In contrast, quasi-experimental methods were the least frequently used, reflecting limitations or specific needs in the application of such methods.

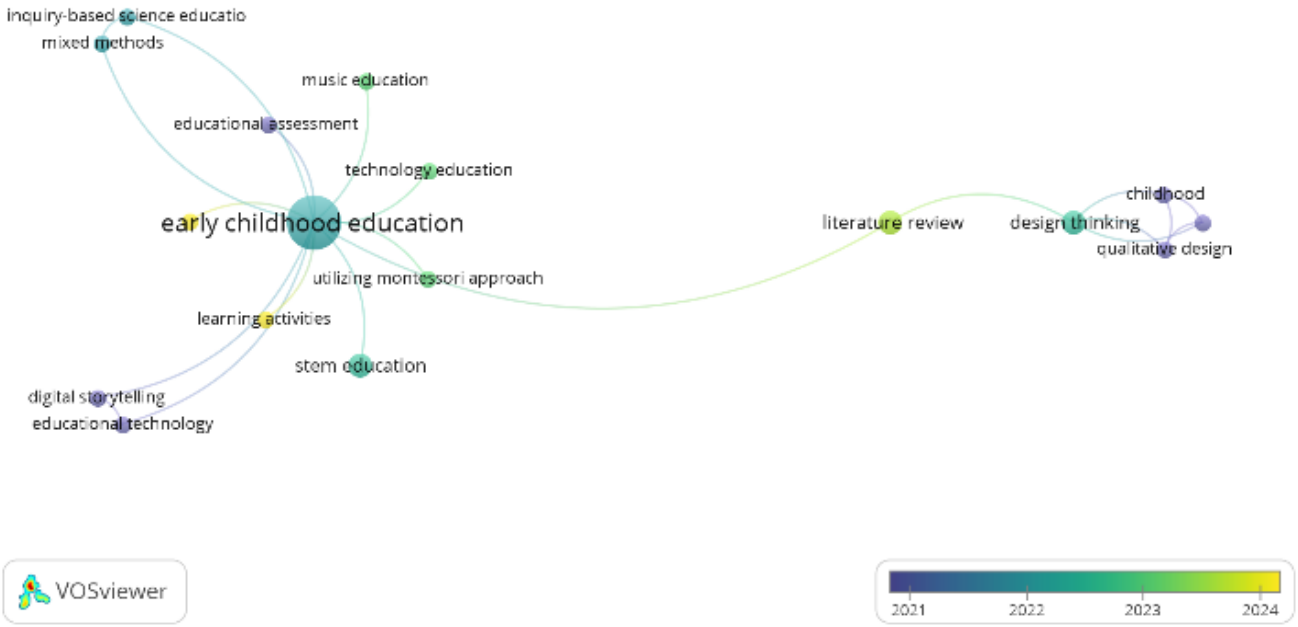

Figure 5. Result

The image from VOSviewer is a bibliometric visualization showing the relationship between topics in research related to science learning in early childhood, with several branches of concepts such as Montessori approach, educational technology, digital storytelling, STEM education, and design thinking. The colors in the graph show the temporal progression (from 2021 to 2024), with recent research trends tending to be related to literature review, design thinking and qualitative design. In the context of a systematic study of science literacy, this figure can provide insights into how the approaches, methods and media used in early childhood science learning are evolving.

Early Childhood Science Learning Approaches

Various approaches have been developed to enhance science learning for young children. The Montessori approach emphasizes sensory-based and exploratory learning with real manipulatives, allowing children to learn through hands-on experience (Nwabuwe & Osagiede, 2023). Digital and Interactive Media-Based Approaches utilize technology such as touch screens and conversational agents to enhance children's engagement in understanding science concepts (Liu & Hwang, 2023; Rahiem, 2021). Contextualized and Experiential Approaches help children build understanding through hands-on experiences relevant to everyday life (Aydin-Ceran, 2021).

In addition, the Scientific Approach focuses on observation, exploration and experimentation based on scientific logic, so that children can develop critical thinking skills (Bustamante et al., 2018; Wulandari et al., 2023). Design Thinking encourages creative exploration in science learning, allowing children to find innovative solutions to problems (Grönman et al., 2024). Finally, the Multidisciplinary Approach combines science with art, technology and other aspects to create a more holistic and integrated learning experience (Tramonti & Tramonti, 2018).

Early Childhood Science Learning Methods

From the data obtained, there are several methods that are often used in science learning for early childhood. The Inquiry-Based Learning method encourages children to ask questions, explore, and draw conclusions through simple experiments (Golubović-Ilić & Ćirković-Miladinović, 2020; Mellander & Svärdh,

2018). The Problem-Based Learning approach helps children solve real problems through experimentation and exploration, allowing them to develop critical thinking skills (Alberida, 2020).

In addition, Collaborative Learning emphasizes the interaction between children and their social environment to build understanding in science learning (Ferreira, 2023; Gealy et al., 2022). Project-Based Learning engages children in longer and sustained scientific exploration projects, providing opportunities to deepen science concepts (Kiliç, 2022; Napitupulu et al., 2024). The STEAM/STEM approach integrates science with technology, engineering, art and math to enhance children's understanding of the world around them (Ellizah et al., 2020; Jelita & Mazlan, 2023; Su & Yang, 2024). Finally, Nature-Based Learning and Gardening Education allows children to learn science through exploration of the natural environment, such as gardening activities that provide hands-on experience of ecological concepts and plant growth (Agustina et al., 2023; Ishak & Utoyo, 2020).

Early Childhood Science Learning Media

Some of the media often used in early childhood science learning include Digital Storytelling (Rahiem, 2021), which utilizes digital-based stories to explain science concepts in an engaging way, and Conversational Agents and Digital Media (Xu, 2020), which uses interactive virtual agents to support science learning. In addition, STEAM-Based Games present technology-based games to enhance children's understanding of science concepts (Espigares-Gámez et al., 2020; Lý, 2022). Learning Animations and Videos use animated media and interactive videos to attract children's attention and facilitate understanding of science concepts (Rahayuningsih, 2020; Raynal et al., 2022). Educational Robots introduce STEM concepts through simple robots (Holmquist et al., 2024).

The Reggio Emilia approach applies science exploration through the use of natural materials and used items as creative learning media (Madyawati et al., 2021). Science Storybooks and Science Comics present science concepts in an interesting and easy-to-understand visual form (Hightower et al., 2022). Finally, Virtual and Augmented Reality-Based Environments (Su & Yang, 2023) offer a more immersive science exploration experience through advanced digital technology.

Conclusion

This study highlights the importance of implementing diverse, experiential approaches in early childhood science learning to enhance children's understanding and engagement. Inquiry-based learning, problem-based learning, and project-based learning have proven effective in fostering exploration and critical thinking, while technology-based approaches such as digital storytelling, conversational agents, and augmented reality provide engaging, interactive learning experiences. The findings align with the research objective of analyzing the trends, methods, and media used in early childhood science education, as evidenced by the increasing number of publications up to 2023, predominantly employing qualitative methods to explore children's learning experiences. The bibliometric analysis further reveals a growing focus on STEM education, design thinking, and literature review, reflecting shifts in research priorities. These findings suggest that integrating hands-on exploration, collaboration, and digital tools into early childhood science instruction can improve scientific literacy and inquiry skills. For educators, this study underscores the need to adopt innovative teaching strategies that align with child development theories and emerging technological advancements. Future research should further examine the effectiveness of specific methods and media in various cultural and educational contexts to optimize science learning experiences for young children.

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Author Contributions

This work was completed with the collaboration of all authors. R.A.L. and N.R. were responsible for data collection, screening and analysis, and E.S. was in charge of draft review and editing, supervision and validation. R. was responsible for translation and grammar checking. All authors have read and approved the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

References

Agustina, R., Fatmawati, F. A., Zahriani, F., Zulwati, P. R., Fauziah, S., Faridah, I., Hartanti, T., Insyaroh, N., & Ardiansyah, H. (2023). Gardening Education in Early Childhood: Important Factors Supporting the Success of Implementing It. *Gateways*, *16*(1), 1–13. https://doi.org/10.5130/ijcre.v16i1.8478

Alberida, H. (2020). The Implementation of Scientific Approach in Learning Science Through Problem

Solving. *Proceedings of the International Conference on Biology, Sciences and Education (ICoBioSE 2019)*, 349–353. https://doi.org/10.2991/absr.k.200807.071

Aydin-Ceran, S. (2021). Contextual Learning and Teaching Approach in 21st Century Science Education. *Current Studies in Social Sciences 2021*, 160–173. Retrieved from https://www.isres.org/contextual-learning-and-teaching-approach-in-21st-century-science-education-321-s.html

Bustamante, A. S., White, L. J., & Greenfield, D. B. (2018). Approaches to Learning and Science Education in Head Start: Examining Bidirectionality. *Early Childhood Research Quarterly*, *44*, 34–42. https://doi.org/10.1016/j.ecresq.2018.02.013

Candra, K. I., Hermawan, Y., & Suyantri, E. (2025). Tourism-Based Community Empowerment of People with Disabilities. *Jurnal Penelitian Pendidikan IPA*, *11*(1), 163–175. https://doi.org/10.29303/jppipa.v11i1.9839

Carulla, C. V., Christodoulakis, N., & Adbo, K. (2021). Development of Preschool Children's Executive Functions Throughout a Play-Based Learning Approach That Embeds Science Concepts. *International Journal of Environmental Research and Public Health*, *18*(2), 1–11. https://doi.org/10.3390/ijerph18020588

Counsell, S. L. (2022). The Early Years: Preschoolers' Science Learning Can Be Joyful—Using a Play-Based, Project Approach. *Science and Children*, *60*(1), 6–7. https://doi.org/10.1080/19434812.2022.12291812

Dibyantini, R. E., Amdayani, S., Siregar, M. I., & Syafriani, D. (2023). Application of STEM-PjBL Based Chemistry Module to Improve Science Literacy and Student Learning Motivation. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 95–102. https://doi.org/10.29303/jppipa.v9ispecialissue.5872

Ellizah, D. L., Aerin, W., Istiningsih, I., & Rokhimawan, M. A. (2020). Planning of PAUD Learning with STEAM (Science Technology, Art, and Math) Approach. *Indonesian Journal of Early Childhood Education Studies*, *9*(2), 67–72. Retrieved from https://journal.unnes.ac.id/sju/index.php/ijeces

Espigares-Gámez, M. J., Fernández-Oliveras, A., & Oliveras, M. L. (2020). Games as STEAM Learning Enhancers. Application of Traditional Jamaican Games in Early Childhood and Primary Intercultural Education. *Acta Scientiae*, *22*(4), 28–50. https://doi.org/10.17648/ACTA.SCIENTIAE.6019

Ferreira, J. M. (2023). An Embodied View on Collaboration in Early Childhood Education: Combining Microanalysis and Introspective Analysis of Experiences to Understand Meaning-Making Between Children with and without Intellectual Disabilities. *Human Arenas*, *0123456789*. https://doi.org/10.1007/s42087-023-00380-4

Gealy, A. M., Tinney, G., Macdonald, N., & Waters, J. (2022). A Socio-Constructivist Approach to Developing a Professional Learning Intervention for Early Childhood Education and Care Practitioners in Wales. *Professional Development in Education*, *48*(2), 298–314. https://doi.org/10.1080/19415257.2020.1742187

Golubović-Ilić, I., & Ćirković-Miladinović, I. (2020). Learning Science in Preschool by Using Research Approach. *Acta Didactica Napocensia*, *13*(1), 77–86. https://doi.org/10.24193/adn.13.1.8

Grönman, S., Lindfors, E., & Rönkkö, M. L. (2024). Design Thinking in Early Childhood Education and Care: A Literature Review and Consideration from the Perspective of Young Learners' Craft, Design, and Technology Education. *International Journal of Technology and Design Education*, *0123456789*. https://doi.org/10.1007/s10798-024-09944-z

Habibi, M. M. (2023). Strategies for Enhancing Early Childhood Science Literacy Through STEAM Education. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 11767–11772. https://doi.org/10.29303/jppipa.v9i12.4960

Hightower, B., Sheehan, K. J., Lauricella, A. R., & Wartella, E. (2022). "Maybe We Do More Science Than I Had Initially Thought": How Parental Efficacy Affects Preschool-Aged Children's Science and Math Activities and Media Use. *Early Childhood Education Journal*, *50*(6), 1021–1033. https://doi.org/10.1007/s10643-021-01231-z

Holmquist, S., Catlin, D., & Hicks, F. (2024). *Using Simple Using Educational Robots as a Technology for Teaching Early Childhood and Primary Education Literacy in the United States*. Retrieved from https://easychair.org/publications/preprint_download/f3LT

Ishak, D., & Utoyo, S. (2020). Development of Central Learning Model Natural Materials Through the Paud Science Science Approach in the Limboto. *JournalNX*, *6*(7), 99–105. Retrieved from https://www.academia.edu/download/63917967/20151462-central-learning-model20200714-84482-193fnkf.pdf

Jelita, J., & Mazlan, M. (2023). The Effectiveness of the Science, Technology, Engineering, Art, Mathematics, and Religious (STEAM.R) Approach on Students' Concept Understanding in Science Learning: An Analysis Based on Gender. *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran dan Pembelajaran*, *9*(3), 1040. https://doi.org/10.33394/jk.v9i3.8303

Kiliç, İ. (2022). A Qualitative Examination of Parents' Views on the Applicability of the Project-Based Learning Approach in Science Courses. *African Educational Research Journal*, *10*(2), 190–199. https://doi.org/10.30918/aerj.102.22.031

Kurniawan, L., Kuswanto, H., & Dwandaru, W. S. B. (2024). The Use of Scaffolding in Physics Learning: A Systematic Review. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *9*(2), 200. https://doi.org/10.26737/jipf.v9i2.5082

Lestari, H., Setiawan, W., & Siskandar, R. (2020). Science Literacy Ability of Elementary Students Through Nature of Science-Based Learning with the Utilization of the Ministry of Education and Culture's "Learning House." *Jurnal Penelitian Pendidikan IPA*, *6*(2), 215–220. https://doi.org/10.29303/jppipa.v6i2.410

Liu, C., & Hwang, G. J. (2023). Roles and Research Trends of Touchscreen Mobile Devices in Early Childhood Education: Review of Journal Publications from 2010 to 2019 Based on the Technology-Enhanced Learning Model. *Interactive Learning Environments*, *31*(3), 1683–1702. https://doi.org/10.1080/10494820.2020.1855210

Lý, B. N. (2022). Designing and Organizing Science Learning Games for Preschool Children at the Age of 5-6 in the STEAM Approach. *Science & Technology Development Journal - Social Science and Humanities*, *6*(2), 1527–1539. https://doi.org/10.32508/stdjssh.v6i2.725

Madyawati, L., Prihati, D., & Rizki, S. F. (2021). *Unused Goods: Science Learning Through Reggio Emilia Approach*. *Proceedings of the 2nd Borobudur International Symposium on Humanities and Social Sciences, BIS-HSS 2020*. 18 November 2020, Magelang, Central Java, Indonesia, 1–6. https://doi.org/10.4108/eai.18-11-2020.2311715

Matahari, D. B., Nurohman, S., & Jumadi, J. (2023). Research Trends in Project-Based Learning Models in Facilitating 21st Century Skills: Systematic Literature Review. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 1607–1614. https://doi.org/10.29303/jppipa.v9i4.2544

Mateeva, A., Hristova, P., & Koltcheva, N. (2022). *Kindergarten Teachers' Implicit Knowledge on Child's Science Participation from Their Experience with 3-4 Years Old Children from Roma Community in Sofia*. 1–23. Retrieved from https://kognitivna-nauka-i-psihologija.nbu.bg/download/departamenti/cognitivna-nauka-i-psihologia/presentations2/mateeva-a-at-al-kindergarten-teachers-implicit-knowledge.pdf

Mellander, E., & Svärdh, J. (2018). Inquiry-Based Learning Put to the Test: Medium-Term Effects of a Science and Technology for Children Programme. *Review of Education*, *6*(2), 103–141. https://doi.org/10.1002/REV3.3109

Napitupulu, N. D., Hutahaean, J., & Fauziyyah, A. N. L. (2024). Trends Research Project Based Learning (PjBL) Model to Improve Science Process Skills in Students' Science Learning (2015-2024): A Systematic Review. *Jurnal Penelitian Pendidikan IPA*, *10*(7), 488–497. https://doi.org/10.29303/jppipa.v10i7.8577

Nursakinah, S., & Suyanta, S. (2023). Influence of Models Discovery Learning to Critical Thinking Ability and Scientific Attitude of Students. *Jurnal Penelitian Pendidikan IPA*, *9*(10), 8879–8889. https://doi.org/10.29303/jppipa.v9i10.4792

Nwabuwe, H. I., & Osagiede, M. A. (2023). Teaching Effectiveness in the Utilization of Montessori Approach in Early Childhood Basic Science Learning in Ika South Local Government Area (LGA) in Delta State. *International Journal of Humanities and Innovation (IJHI)*, *6*(1), 26–31. https://doi.org/10.33750/ijhi.v6i1.177

Rahayuningsih, S. (2020). Animation Media of Animal Husbandry Thematic Science Learning to Stimulate Scientific Attitude in Early Childhood. *International Journal of Scientific and Technology Research*, *9*(2), 5879–5882.

Rahiem, M. D. H. (2021). Storytelling in Early Childhood Education: Time to Go Digital. *International Journal of Child Care and Education Policy*, *15*(1). https://doi.org/10.1186/s40723-021-00081-x

Raynal, A., Lavigne, H., Goldstein, M., & Gutierrez, J. (2022). Starting with Parents: Investigating a Multi-Generational, Media-Enhanced Approach to Support Informal Science Learning for Young Children. *Early Childhood Education Journal*, *50*(5), 879–889. https://doi.org/10.1007/s10643-021-01209-x

Sriwarthini, N. L. P. N., Astini, B. N., & Gunawan, G. (2023). Analysis of Early Childhood Pre-Service Teacher's Science Concepts Comprehension Based on Their Science Process Skill. *Jurnal Penelitian Pendidikan IPA*, *9*(2), 906–911. https://doi.org/10.29303/jppipa.v9i2.3241

Su, J., & Yang, W. (2023). STEM in Early Childhood Education: A Bibliometric Analysis. *Research in Science and Technological Education*, *42*(4), 1020–1041. https://doi.org/10.1080/02635143.2023.2201673

Su, J., & Yang, W. (2024). AI Literacy Curriculum and Its Relation to Children's Perceptions of Robots and Attitudes Towards Engineering and Science: An Intervention Study in Early Childhood Education. *Journal of Computer Assisted Learning*, *40*(1), 241–253. https://doi.org/10.1111/jcal.12867

Tramonti, M., & Tramonti, L. (2018). Facilitating Science Learning through a Multidisciplinary Approach

Facilitating Science Learning through a Multidisciplinary Approach. *Conference: International Pixel Conference - New Perspectives in Science Education*, 2–4. Retrieved from https://www.researchgate.net/publication/324151671

Westhisi, S. M., Atika, A. R., & Zahro, I. F. (2019). Pengembangan Literasi Sains untuk Anak Usia Dini Kelompok B. *Jurnal Tunas Siliwangi*, *10*(10), 31–36. Retrieved from http://www.e-journal.stkipsiliwangi.ac.id/index.php/tunas-siliwangi/article/view/1491

Wulandari, A. P., Salsabila, A. A., Cahyani, K., Nurazizah, T. S., & Ulfiah, Z. (2023). Pentingnya Media Pembelajaran dalam Proses Belajar Mengajar. *Journal on Education*, *5*(2), 3928–3936. https://doi.org/10.31004/joe.v5i2.1074

Xu, Y. (2020). Using Conversational Agents to Foster Young Children's Science Learning from Screen Media. *Extended Abstracts - Proceedings of the 2020 ACM Interaction Design and Children Conference, IDC 2020*, 14–19. https://doi.org/10.1145/3397617.3398031

Yulianti, E., & Zhafirah, N. N. (2020). Analisis Komprehensif pada Implementasi Pembelajaran dengan Model Inkuiri Terbimbing: Aspek Penalaran Ilmiah. *Jurnal Penelitian Pendidikan IPA*, *6*(1), 125–130. https://doi.org/10.29303/jppipa.v6i1.341

Zamzam, R., Kusmawati, A., Ichsan, I. Z., & Puspitasari, P. R. (2023). Zero Waste Knowledge and Behavior of Early Childhood Pre-Service Teacher in Science Education. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 10590–10595. https://doi.org/10.29303/jppipa.v9i12.5464