https://nawalaeducation.com/index.php/JOG/index
Volume 3 Nomor 1, 2026
e-ISSN : 3047-6259
DOI : https://doi.org/10.62872/pjmbng50

Integrating the STEAM Approach in Early Childhood Education to Develop Critical and Creative Thinking Skills

Nurtina Irsad Rusdiani✉
Universitas Muhammadiyah Ponorogo, Indonesia
e-mail: *tinairsadrusdiani@gmail.com

INFO ARTIKEL

Accepted :
February 02, 2026
Revised :
March 01, 2026
Approved:
March 17, 2026

Keywords:
Creative Thinking, Critical Thinking, Early Childhood Education, STEAM Learning, Interdisciplinary Learning

ABSTRAK

The development of critical and creative thinking skills has become an important priority in early childhood education as part of preparing children to face the challenges of the twenty-first century. Early childhood learning environments should therefore encourage exploration, problem-solving, and creativity through meaningful and interactive activities. One innovative approach that supports these objectives is the STEAM approach, which integrates Science, Technology, Engineering, Arts, and Mathematics into interdisciplinary learning experiences. This study aims to analyze how the integration of the STEAM approach in early childhood education contributes to the development of children's critical and creative thinking skills. This research employs a mixed-method approach involving qualitative and quantitative analysis. Data were collected through classroom observations, teacher interviews, and documentation of STEAM-based learning activities conducted with children aged 4–6 years in early childhood education settings. The collected data were analyzed using thematic analysis for qualitative findings and descriptive statistics to examine improvements in children's thinking skill indicators. The findings indicate that STEAM-based learning significantly improves children's ability to observe, ask questions, experiment, generate original ideas, and collaborate in problem-solving activities. These learning experiences also enhance children's engagement, creativity, and early scientific literacy through hands-on exploration and interdisciplinary activities. In conclusion, the integration of the STEAM approach in early childhood education effectively supports the development of critical and creative thinking skills while creating meaningful and engaging learning environments for young learners.

INTRODUCTION

Early childhood education (ECE) plays a crucial role in shaping children's cognitive, social, and emotional development. During early childhood, children experience rapid brain growth and cognitive development that significantly influence

their ability to observe, explore, question, and interpret the world around them. This developmental stage is therefore considered a critical period for cultivating fundamental thinking skills that support lifelong learning. In the context of twenty-first century education, the development of critical and creative thinking has become one of the primary educational priorities, as these competencies are essential for enabling individuals to adapt to increasingly complex social, technological, and economic environments. Children who develop these skills early are more capable of analyzing information, generating innovative ideas, and solving problems creatively in everyday life situations. Consequently, early childhood education must provide learning environments that encourage exploration, curiosity, experimentation, and creativity in order to foster the development of higher-order thinking skills (Gusmaniarti et al., 2025).

Critical thinking in early childhood is reflected in children's ability to observe phenomena, ask meaningful questions, analyze experiences, and draw conclusions based on their understanding of the environment. Creative thinking, on the other hand, manifests through imagination, originality, and the ability to produce new ideas or alternative solutions to everyday challenges. These two cognitive abilities are closely interconnected and mutually reinforcing, as critical thinking enables children to evaluate ideas logically while creative thinking allows them to generate innovative possibilities. Developing both abilities simultaneously is therefore essential in early childhood education to prepare children for future learning challenges. However, many early childhood learning practices still rely heavily on teacher-centered instruction and rote memorization, which limit opportunities for children to actively engage in exploration and creative problem-solving. Such approaches may hinder the development of critical and creative thinking skills because they position children as passive recipients of information rather than active participants in the learning process (Gusmaniarti et al., 2025).

In response to these challenges, educational researchers and practitioners have increasingly emphasized the importance of adopting innovative pedagogical approaches that promote active, inquiry-based learning. One such approach that has gained considerable attention in recent years is the STEAM approach, which integrates Science, Technology, Engineering, Arts, and Mathematics into interdisciplinary learning experiences. The STEAM approach emphasizes hands-on exploration, problem-solving, creativity, and collaboration as key components of meaningful learning. By integrating scientific inquiry with artistic creativity and technological exploration, STEAM-based learning encourages children to develop a holistic understanding of knowledge while simultaneously strengthening their cognitive and creative abilities. This interdisciplinary approach aligns well with the developmental characteristics of early childhood learners, who naturally explore the world through curiosity, experimentation, and play-based learning (Violy, 2025).

Numerous studies have demonstrated the potential of STEAM-based learning to enhance critical thinking, creativity, and problem-solving skills among young learners. Through activities that combine experimentation, design thinking, and artistic expression, children are encouraged to explore problems from multiple perspectives and develop innovative solutions. Research findings indicate that STEAM learning activities that incorporate traditional games and cultural elements can significantly improve children's creativity, early science understanding, and mathematical reasoning. Such learning experiences allow children to connect theoretical knowledge with practical exploration, thereby strengthening their cognitive engagement and motivation to learn.

`The integration of STEAM with play-based learning also provides opportunities for children to develop communication and collaboration skills, which are essential competencies for social interaction and teamwork in modern educational contexts (Made et al., 2025).

Another important contribution of the STEAM approach is its ability to enhance early scientific literacy and STEAM literacy among children. Scientific literacy in early childhood refers to the ability to observe natural phenomena, formulate simple explanations, and engage in inquiry-based exploration of the surrounding environment. Studies have shown that STEAM-based experimental activities can significantly improve children's understanding of scientific concepts and processes. For instance, hands-on experiments involving simple materials such as balloons or water-based activities have been found to increase children's scientific literacy levels substantially. These findings demonstrate that STEAM-based learning can effectively introduce scientific thinking and inquiry processes at an early age, thereby laying the foundation for more advanced learning in later educational stages (Habibi, 2023).

In addition to cognitive development, STEAM learning has also been associated with increased engagement and collaboration among early childhood learners. Project-based learning (PBL) and problem-based learning (PjBL) models integrated with STEAM principles encourage children to work collaboratively, share ideas, and participate actively in problem-solving activities. Such collaborative learning environments promote social interaction and communication skills while simultaneously supporting cognitive development. Research indicates that children who participate in STEAM-based project activities demonstrate higher levels of engagement, curiosity, and collaborative behavior compared to those who experience traditional instructional approaches. These findings highlight the potential of STEAM learning to create dynamic and interactive educational environments that support holistic child development (Harjanty & Muzdalifah, 2022).

Despite the growing interest in STEAM education, research on the integration of STEAM approaches in early childhood education remains relatively limited. Several systematic reviews indicate that the implementation of STEAM in early childhood contexts is still emerging and unevenly distributed across educational systems. Many existing studies focus primarily on primary or secondary education, while research specifically addressing STEAM implementation in early childhood settings is less common. This imbalance suggests that further research is needed to explore how STEAM learning can be effectively adapted to the developmental needs of young children. Understanding the pedagogical principles and learning strategies that support successful STEAM implementation in early childhood education is therefore essential for expanding the use of this approach in educational practice (Su et al., 2024).

Another significant challenge related to STEAM implementation in early childhood education concerns the limited pedagogical knowledge and confidence of teachers in applying interdisciplinary learning strategies. Many early childhood educators report uncertainty about how to design STEAM-based learning activities or integrate multiple disciplines into cohesive lesson plans. In addition, the absence of clear curriculum guidelines and instructional resources often makes it difficult for teachers to implement STEAM effectively in classroom practice. Without adequate professional development and instructional support, teachers may struggle to facilitate inquiry-based learning experiences that fully utilize the potential of the STEAM approach. These challenges highlight the importance of developing teacher training programs and

pedagogical frameworks that support the integration of STEAM in early childhood education (Munyif, 2025).

Furthermore, cultural and contextual factors also influence the implementation of STEAM learning in different educational environments. Educational practices and learning resources vary significantly across countries and communities, which means that STEAM approaches must be adapted to local cultural contexts in order to remain relevant and meaningful for learners. Some researchers have emphasized the importance of incorporating culturally responsive teaching strategies and local knowledge into STEAM-based learning activities. Integrating local traditions, cultural practices, and community experiences into STEAM learning can help create educational experiences that are both culturally meaningful and intellectually stimulating for young learners. Such contextual adaptation also ensures that STEAM education becomes more inclusive and accessible to diverse educational communities (Najanuddin et al., 2023).

Based on these considerations, several scholars have suggested that future research should focus on developing clearer models and frameworks for integrating STEAM in early childhood education. For example, the concept of inSTEAM has been proposed as a pedagogical framework that emphasizes interdisciplinary integration and collaborative learning. Additionally, longitudinal studies are needed to examine the long-term impact of STEAM-based learning on children's cognitive and creative development. Understanding how STEAM experiences influence children's thinking skills over extended periods of time would provide valuable insights into the effectiveness of this approach as a sustainable educational strategy (Ng et al., 2022).

Considering the existing research gaps and practical challenges, this study offers a novel contribution by examining the integration of the STEAM approach in early childhood education with a specific focus on developing critical and creative thinking skills among young learners. Unlike previous studies that often examine STEAM learning in broader educational contexts, this research emphasizes its application within early childhood settings and explores how interdisciplinary learning activities can stimulate children's cognitive and creative development simultaneously. By analyzing the pedagogical implementation of STEAM-based learning in early childhood classrooms, this study seeks to provide insights into effective teaching strategies that support the development of critical and creative thinking skills in young children.

Therefore, the objective of this study is to analyze how the integration of the STEAM approach in early childhood education can support the development of critical and creative thinking skills among young learners. Through this analysis, the study aims to contribute to the growing body of research on innovative early childhood pedagogy and to provide practical recommendations for educators seeking to implement STEAM-based learning in early childhood educational settings.

METHODOLOGY

This study employs a mixed qualitative–quantitative approach to examine the integration of the STEAM approach in early childhood education and its impact on the development of children's critical and creative thinking skills. The research is conducted in early childhood education (PAUD) institutions that have implemented or are beginning to adopt STEAM-based learning activities. The participants consist of early childhood learners aged 4–6 years and teachers who facilitate STEAM learning in the classroom. The sampling technique used is purposive sampling, in which participants are selected based on specific criteria such as participation in STEAM learning activities and the

relevance of the learning environment to the research objectives. The primary data are collected through classroom observation, teacher interviews, and documentation of learning activities, while secondary data are obtained from curriculum documents, lesson plans, and related educational reports. Observation is used to identify how STEAM-based activities are implemented in classroom learning and how children demonstrate critical and creative thinking during the learning process. Interviews with teachers are conducted to explore their perspectives regarding STEAM implementation, learning strategies, and challenges encountered during instruction.

The data analysis process is conducted through both qualitative and quantitative procedures. Qualitative data obtained from observations, interviews, and documentation are analyzed using thematic analysis to identify patterns related to STEAM learning practices and the development of children's thinking skills. The analysis includes several stages, namely data reduction, data categorization, interpretation, and drawing conclusions regarding how STEAM integration supports critical and creative thinking development. Meanwhile, quantitative data derived from observational assessment instruments are analyzed using descriptive statistics to measure the level of improvement in children's critical and creative thinking indicators during STEAM-based activities. These indicators include the ability to ask questions, propose ideas, solve simple problems, experiment with materials, and express creative solutions. The integration of qualitative and quantitative findings allows the study to provide a comprehensive understanding of how STEAM-based learning contributes to the development of critical and creative thinking skills in early childhood education.

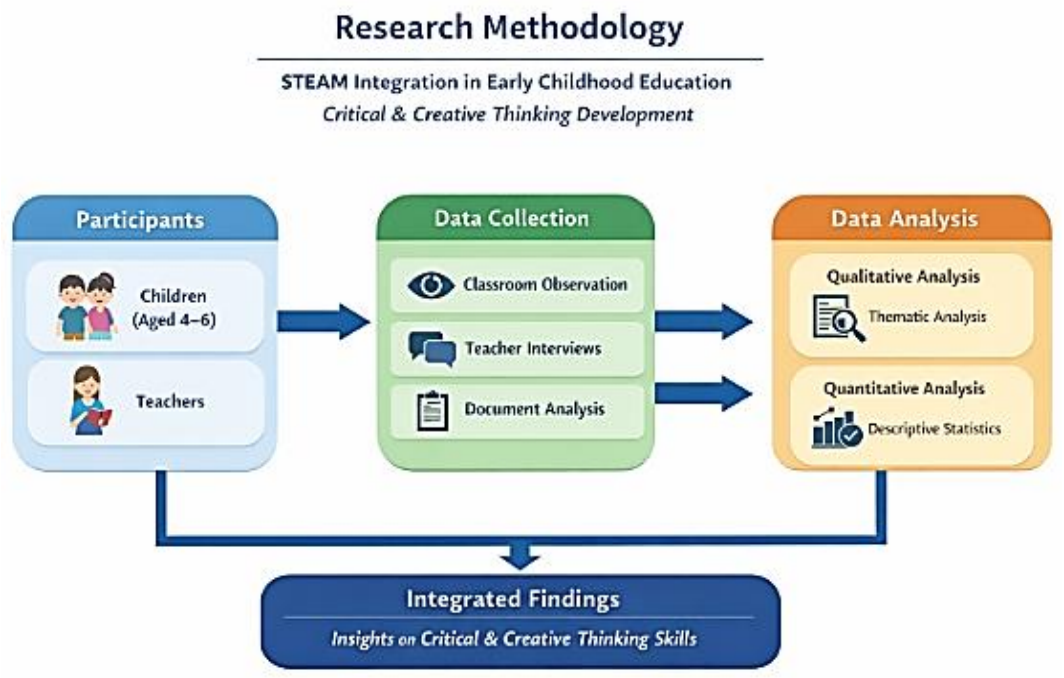

Figure 1. Diagram Conceptual Research

RESULTS AND DISCUSSION

To examine the impact of STEAM-based learning on the development of critical and creative thinking skills among early childhood learners, observational assessments were conducted during several STEAM learning sessions implemented in the classroom. The assessment focused on key indicators of critical thinking and creative thinking

demonstrated by children during hands-on activities such as experimentation, collaborative problem solving, and creative project development. Each indicator was evaluated using an observational rubric with a four-point scale ranging from low to very high development. The results of the assessment are summarized in Table 1.

Table 1. Development of Critical Thinking Skills in STEAM-Based Learning Activities

Critical Thinking Indicators	Percentage of Children (Before Implementation)	Percentage of Children (After STEAM Implementation)
Ability to observe and identify problems	42%	76%
Ability to ask questions during learning activities	38%	72%
Ability to explain simple phenomena	35%	70%
Ability to evaluate or compare outcomes	31%	68%
Ability to propose simple solutions	33%	74%

Based on Table 1, the findings indicate a noticeable improvement in children's critical thinking skills after the implementation of STEAM-based learning activities. Prior to the integration of STEAM, most children demonstrated limited engagement in analytical thinking processes such as questioning, evaluating outcomes, and proposing solutions. However, after participating in STEAM-based exploratory activities, the proportion of children demonstrating these critical thinking indicators increased significantly. The results suggest that STEAM learning provides opportunities for children to engage in inquiry, experimentation, and reflective thinking, which collectively support the development of early critical thinking abilities.

In addition to critical thinking development, the research also assessed children's creative thinking skills during STEAM-based activities. Creativity indicators were observed through children's ability to generate ideas, experiment with materials, collaborate with peers, and produce original creations during project-based learning tasks. The results of the creative thinking assessment are presented in Table 2.

Table 2. Development of Creative Thinking Skills in STEAM-Based Learning Activities

Creative Thinking Indicators	Percentage of Children (Before Implementation)	Percentage of Children (After STEAM Implementation)
Ability to generate original ideas	40%	78%
Ability to experiment with materials creatively	37%	80%
Ability to develop imaginative solutions	35%	74%

Ability to collaborate in creative activities	45%	83%
Ability to express ideas through artistic creation	39%	81%

The results in Table 2 demonstrate that the integration of STEAM-based learning significantly enhances children's creative thinking abilities. Prior to the implementation of STEAM, creative engagement was relatively limited, with many children relying on guided instructions rather than initiating their own ideas. After participating in STEAM activities, however, children showed greater enthusiasm for experimentation, imaginative thinking, and artistic expression. The increase in collaborative creativity also indicates that STEAM learning environments encourage interaction and collective problem solving among children. These findings suggest that STEAM-based learning provides a supportive framework for nurturing creativity and innovation in early childhood education while simultaneously promoting active participation and exploratory learning experiences.

Discussion

The findings presented in Tables 1 and 2 indicate that the integration of the STEAM approach in early childhood education significantly contributes to the development of children's critical and creative thinking skills. The results show a substantial increase in indicators such as the ability to observe phenomena, ask questions, evaluate outcomes, generate original ideas, and experiment creatively with materials after STEAM-based learning activities were implemented. These improvements demonstrate that interdisciplinary learning environments that combine exploration, experimentation, and creative expression provide meaningful opportunities for young learners to develop higher-order thinking skills. In early childhood education, the development of such cognitive abilities is particularly important because this stage represents a foundational period for shaping children's intellectual curiosity, problem-solving abilities, and creative imagination. Therefore, the integration of STEAM-based learning activities provides a pedagogical framework that aligns with the developmental characteristics of young children while simultaneously fostering the competencies required in the twenty-first century learning context (Gusmaniarti et al., 2025).

The improvement in children's critical thinking indicators observed in this study reflects the effectiveness of STEAM learning in encouraging inquiry-based exploration. Critical thinking in early childhood is typically expressed through behaviors such as observing objects carefully, asking questions about unfamiliar phenomena, explaining simple concepts, and evaluating the results of experiments. When children participate in STEAM-based learning activities, they are encouraged to explore problems through experimentation and collaborative discussion. This active engagement stimulates cognitive processes that involve analysis, reasoning, and evaluation. As demonstrated in Table 1, children showed a considerable increase in their ability to identify problems and propose simple solutions after participating in STEAM learning sessions. These findings support the argument that experiential learning environments play a crucial role in developing children's critical thinking abilities because they allow learners to construct knowledge through direct interaction with their environment (Violy, 2025).

In addition to improving analytical thinking, STEAM learning also fosters creativity among early childhood learners. The results presented in Table 2 show a significant

increase in children's ability to generate original ideas, experiment with materials creatively, and express imaginative solutions during STEAM-based activities. Creative thinking is closely associated with children's capacity to explore possibilities, produce new ideas, and express imagination through artistic or experimental activities. By integrating arts with science and engineering exploration, STEAM learning provides children with opportunities to combine logical reasoning with imaginative thinking. This interdisciplinary integration allows children to experiment with different materials, design creative solutions, and express ideas through multiple forms of representation. As a result, children become more confident in exploring new possibilities and generating innovative ideas during learning activities (Made et al., 2025).

The effectiveness of STEAM learning in promoting both critical and creative thinking can also be explained by its emphasis on problem-solving and inquiry-based learning. STEAM activities often involve real-life problems that encourage children to observe, experiment, and collaborate in finding solutions. Through these processes, children learn to connect theoretical knowledge with practical experiences. For example, science experiments involving simple materials such as balloons or water allow children to observe cause-and-effect relationships and formulate explanations based on their observations. Research findings indicate that such hands-on experimentation significantly improves early science literacy and reasoning abilities among young learners. Habibi (2023) reports that STEAM-based experimental learning activities can increase children's scientific literacy levels dramatically, demonstrating the effectiveness of experiential learning in developing cognitive skills.

Another important dimension of STEAM learning highlighted in this study is its role in enhancing children's engagement and collaborative interaction. Early childhood learners tend to learn more effectively when they are actively involved in playful and collaborative activities rather than passive instruction. STEAM-based project learning encourages children to work together, exchange ideas, and participate in collective problem-solving processes. Such collaborative learning environments promote communication, cooperation, and social interaction while simultaneously supporting cognitive development. The findings of this study reveal that children demonstrated higher levels of participation and enthusiasm during STEAM-based learning activities compared to traditional teacher-centered instruction. These results are consistent with previous studies indicating that project-based STEAM learning enhances children's engagement, curiosity, and collaboration in early childhood classrooms (Harjanty & Muzdalifah, 2022).

Furthermore, the integration of STEAM in early childhood education contributes to the development of interdisciplinary knowledge and early scientific literacy. By combining elements of science, technology, engineering, arts, and mathematics within a single learning experience, STEAM encourages children to view knowledge as interconnected rather than isolated disciplinary domains. This holistic approach supports the development of integrated thinking skills, which are essential for understanding complex real-world problems. For example, when children engage in designing simple structures or creating artistic representations of scientific concepts, they simultaneously apply scientific reasoning, mathematical understanding, and creative expression. Such interdisciplinary learning experiences not only strengthen cognitive skills but also foster curiosity and enthusiasm for learning (Sung et al., 2023).

Despite these positive outcomes, the implementation of STEAM learning in early childhood education still faces several challenges. One of the most commonly identified

challenges is the limited pedagogical knowledge of teachers regarding STEAM-based instruction. Many early childhood educators are unfamiliar with interdisciplinary teaching methods and may feel uncertain about how to integrate science, technology, engineering, arts, and mathematics into cohesive learning activities. Without adequate professional development and instructional support, teachers may find it difficult to design effective STEAM-based learning experiences that align with children's developmental needs. This challenge highlights the importance of teacher training programs that focus on developing pedagogical competencies related to STEAM integration in early childhood classrooms (Munyif, 2025).

In addition to teacher preparedness, another challenge involves the availability of curriculum guidelines and learning resources that support STEAM implementation in early childhood education. In many educational contexts, STEAM has not yet been formally integrated into early childhood curricula, which makes it difficult for educators to adopt the approach systematically. Teachers often rely on their own creativity and improvisation when designing STEAM activities, which may lead to inconsistent implementation across different educational settings. Therefore, the development of clear curriculum frameworks and instructional guidelines is necessary to ensure that STEAM learning can be effectively implemented in early childhood education systems (Su et al., 2024).

Another important issue related to STEAM implementation is the diversity of cultural and educational contexts in which early childhood learning takes place. Educational practices vary significantly across countries and communities, which means that STEAM learning models must be adapted to local cultural environments in order to remain meaningful and relevant. Integrating cultural elements such as traditional games, local materials, and community experiences into STEAM activities can make learning more engaging for children while also preserving cultural identity. Studies suggest that culturally responsive STEAM learning environments enhance children's motivation and participation because they connect new knowledge with familiar experiences from their daily lives (Najanuddin et al., 2023).

Furthermore, recent literature highlights the need for longitudinal research examining the long-term impact of STEAM learning on children's cognitive and creative development. While many studies demonstrate short-term improvements in critical thinking and creativity, fewer studies investigate how these skills evolve over extended periods of time. Longitudinal research would provide valuable insights into whether STEAM-based learning experiences during early childhood contribute to sustained academic success and lifelong learning abilities. Such research could also identify the specific learning experiences that have the greatest impact on children's cognitive development (Ng et al., 2022).

Another direction for future research involves the development of integrated pedagogical frameworks that guide STEAM implementation in early childhood education. One example is the inSTEAM framework, which emphasizes interdisciplinary integration, inquiry-based learning, and collaborative problem-solving as core components of STEAM pedagogy. Such frameworks can provide practical guidance for teachers in designing learning activities that combine multiple disciplines while maintaining developmentally appropriate practices for young learners. By establishing clear pedagogical models, educators can implement STEAM learning more consistently and effectively in early childhood classrooms (Ng, 2024).

Overall, the findings of this study confirm that STEAM-based learning provides a

highly effective pedagogical approach for developing critical and creative thinking skills among early childhood learners. The interdisciplinary and inquiry-based nature of STEAM activities encourages children to engage actively in exploration, experimentation, and creative expression. Through these processes, children develop essential cognitive skills such as problem-solving, analytical reasoning, and imaginative thinking. At the same time, STEAM learning environments foster collaboration, communication, and curiosity, which are essential components of holistic child development.

In conclusion, the discussion demonstrates that the integration of STEAM learning in early childhood education plays a significant role in supporting the development of critical and creative thinking skills. By providing interdisciplinary learning experiences that combine scientific inquiry, artistic creativity, and collaborative problem-solving, STEAM-based learning helps children develop the cognitive and social competencies needed to navigate the challenges of the modern world. These findings reinforce the importance of expanding STEAM research and implementation in early childhood education while also addressing the pedagogical and contextual challenges associated with its adoption.

CONCLUSION

In conclusion, the findings of this study demonstrate that the integration of the STEAM approach in early childhood education plays a significant role in supporting the development of critical and creative thinking skills among young learners. The results indicate that STEAM-based learning activities encourage children to actively observe, ask questions, experiment, generate original ideas, and collaborate with peers in solving problems. Through interdisciplinary and inquiry-based learning experiences that combine science, technology, engineering, arts, and mathematics, children are provided with opportunities to develop analytical reasoning, creativity, and problem-solving abilities in meaningful learning contexts. These findings confirm that STEAM learning not only enhances children's cognitive engagement but also creates a learning environment that stimulates curiosity, imagination, and collaborative exploration. Therefore, the study concludes that the effective integration of STEAM-based pedagogy in early childhood classrooms can serve as a strategic educational approach to foster critical and creative thinking skills that are essential for children's future learning and development.

LITERATURE

Gusmaniarti, G., Mustaji, M., Widodo, W., Suryanti, S., & Wiryanto, W. (2025). Development of DACAR as a new learning model to train critical and creative thinking skills: A study on early childhood education. *Edelweiss Applied Science and Technology.* https://doi.org/10.55214/25768484.v9i6.7872

Habib, M. (2025). Foundations for the future: Integrating problem-based STEAM in early childhood. *Physical Education, Health and Social Sciences.* https://doi.org/10.63163/jpehss.v3i4.799

Habibi, M. (2023). Strategies for enhancing early childhood science literacy through STEAM education. *Jurnal Penelitian Pendidikan IPA.* https://doi.org/10.29303/jppipa.v9i12.4960

Harjanty, R., & Muzdalifah, F. (2022). Implementation of STEAM project-based learning in developing early childhood cooperation. *Atfālunā Journal of Islamic Early Childhood Education.* https://doi.org/10.32505/atfaluna.v5i1.4093

Johnston, K., Kervin, L., & Wyeth, P. (2022). STEM, STEAM and makerspaces in early childhood: A scoping review. *Sustainability.* https://doi.org/10.3390/su142013533

Made, N., Suryaningsih, A., Poerwati, C., Lestari, P., Made, I., & Parwata, Y. (2025). Early childhood literacy skills: Implementation of the local genius-based STEAM learning model. *Indonesian Journal of Educational Development (IJED).* https://doi.org/10.59672/ijed.v6i1.4627

Malaikosa, Y., Adhe, K., & Fauziddin, M. (2025). Development of divergent thinking skills in early childhood through the creative mine adventure application. *Jurnal Pendidikan Anak Usia Dini Undiksha.* https://doi.org/10.23887/paud.v13i2.90123

Munyif, A. (2025). Discovering early childhood educators' perceptions of STEAM education in the Saudi context: A qualitative study. *Journal of Posthumanism.* https://doi.org/10.63332/joph.v5i6.2169

Najanuddin, N., Setiani, R., & Listyowati, A. (2023). Redefining early literacy: A STEAM approach at AZ Zahra NU Kindergarten, Magelang. *Golden Age: Jurnal Ilmiah Tumbuh Kembang Anak Usia Dini.* https://doi.org/10.14421/jga.2023.84-08

Ng, A. (2024). Empowering Malaysian early childhood practitioners' sustainable inclusive practices through the 'integrating and navigating Science, Technology, Engineering, Arts, and Mathematics' (inSTEAM) framework. *Eurasia Journal of Mathematics, Science and Technology Education.* https://doi.org/10.29333/ejmste/15579

Ng, A., Kewalramani, S., & Kidman, G. (2022). Integrating and navigating STEAM (inSTEAM) in early childhood education: An integrative review and inSTEAM conceptual framework. *Eurasia Journal of Mathematics, Science and Technology Education.* https://doi.org/10.29333/ejmste/12174

Rodrigues-Silva, J., & Alsina, Á. (2023). STEM/STEAM in early childhood education for sustainability (ECEfS): A systematic review. *Sustainability.* https://doi.org/10.3390/su15043721

Silva-Hormazábal, M., & Alsina, Á. (2023). Exploring the impact of integrated STEAM education in early childhood and primary education teachers. *Education Sciences.* https://doi.org/10.3390/educsci13080842

Su, J., Yim, I., Wegerif, R., & Chu, S. (2024). STEAM in early childhood education: A scoping review. *Research in Science & Technological Education, 43*, 495–511. https://doi.org/10.1080/02635143.2023.2296445

Sung, J., Lee, J., & Chun, H. (2023). Short-term effects of a classroom-based STEAM program using robotic kits on children in South Korea. *International Journal of STEM Education, 10*, 1–18. https://doi.org/10.1186/s40594-023-00417-8

Violy, A. (2025). Enhancing STEAM skills in early childhood through contextual learning. *Akademika.* https://doi.org/10.34005/ak.v13i02.4303

(2025). Exploring early childhood education teacher's beliefs about STEAM learning in Indonesia. *Southeast Asia Early Childhood Journal.* https://doi.org/10.37134/saecj.vol14.1.7.2025