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The Role of Teachers in Implementing STEAM Learning in Early Childhood Education: A Systematic Literature Review

Annisa Aulia Dewi[1], Hibana Yusuf[2], Lailatu Rohmah[3]
[1,2,3] Pendidikan Islam Anak Usia Dini, Universitas Islam Negeri Sunan Kalijaga, Yogyakarta, Indonesia
e-mail: *[1]anisa.pml10@gmail.com , [2]hibana@uin-suka.ac.id, [3]lailatu.rohmah@uin-suka.ac.id

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ABSTRACT

This study aims to examine the role of teachers in the implementation of STEAM learning (Science, Technology, Engineering, Arts, and Mathematics). The method employed was a Systematic Literature Review (SLR) of 15 national journal articles published between 2021 and 2025, obtained through Google Scholar and selected based on inclusion criteria and research objectives. The results of the analysis indicate that teachers play a central role as facilitators, mediators, and designers of STEAM learning, which is capable of enhancing 21st-century skills such as critical thinking, creativity, communication, and collaboration in children. However, several challenges remain, including an incomplete understanding of the STEAM concept, limited facilities and infrastructure, and minimal integration of Islamic values in learning practices. This study emphasizes the importance of strengthening teacher capacity through training, innovative learning strategies, and

policy support to optimize value-based STEAM implementation in order to shape children's character from an early age.

Introduction

The implementation of the STEAM learning approach (Science, Technology, Engineering, Arts, and Mathematics) in early childhood education has become part of the global educational trend of the 21st century (Suryaningsih, 2025; Yuniar, 2024). The application of STEAM learning aims to foster critical thinking, creativity, collaboration, and communication skills from an early age as a foundation for facing the challenges of the digital era and the Industrial Revolution 4.0 (Mukarramah, 2023; Nuragnia et al., 2021). In various countries, teachers play a key role in the successful implementation of STEAM, acting as facilitators, learning designers, and drivers of innovation (Munawar, 2025; Putra, 2025). In Indonesia, challenges such as limited teacher understanding as well as inadequate facilities and infrastructure remain major concerns in the development of STEAM-based early childhood curricula (Mulyana, 2023). Therefore, the significance of this study lies in strengthening the role of teachers in implementing STEAM learning through an integrative approach to shape children's character, not only intellectually competent but also morally grounded.

Research on the implementation of STEAM learning in early childhood education has been widely conducted with various focal points. For instance, Munawar (2025) emphasized that the role of teachers as facilitators and mediators is crucial in improving children's

critical thinking and collaboration skills through STEAM-based learning. Kurniati (2024) also demonstrated that teachers who are able to design creative activities and understand STEAM principles can overcome implementation challenges in the classroom. Marliani (2025) added that the success of STEAM learning is influenced by teacher readiness, both conceptually and technically, as well as environmental support. Meanwhile, Mulyana (2023) revealed that many teachers still hold perceptions that are not fully aligned with integrative 21st-century STEAM principles. Adzani et al. (2024) further found a significant relationship between teachers' pedagogical competence and the successful implementation of STEAM. Other studies, such as those by Aprilia (2022) and Anggreani (2022), emphasized the importance of indirect learning strategies and teacher training in improving the quality of STEAM implementation. Overall, these findings indicate that strengthening teacher capacity is a key factor in realizing effective STEAM learning at the early childhood education level.

Although previous studies have examined the role of teachers and the implementation of STEAM learning in early childhood education, most of them have focused on technical aspects of implementation, learning strategies, and general teacher readiness and competence (Munawar, 2025; Aprilia, 2022; Kurniati, 2024). Studies by Mulyana (2023) and Marliani (2025) also highlighted limitations in teachers' understanding of comprehensive STEAM concepts and the lack of interdisciplinary integration in classroom practices. However, there is

still limited research that specifically links the STEAM approach with Islamic values, particularly hadith, in shaping children's character from an early age. This represents a significant research gap that needs to be addressed, namely how teachers can implement STEAM learning that not only develops cognitive and creative competencies but also instills moral and spiritual values. Therefore, this study is directed at filling this gap by focusing on the integration of STEAM learning and character education in the context of early childhood education.

In the era of globalization and technological advancement of the 21st century, early childhood education (ECE) is required to prepare a generation that is not only intellectually capable but also possesses critical, creative, and collaborative thinking skills (Yuniar, 2024). The STEAM learning approach has been widely adopted as it integrates various disciplines relevant to contemporary needs. On the other hand, Islamic values, particularly those derived from hadith, play an important role in shaping children's character and moral development from an early age. This study focuses on the role of teachers in implementing integrated STEAM learning within the context of early childhood education. The objective is to describe how teachers design, implement, and develop STEAM learning activities that not only foster 21st-century competencies but also strengthen children's moral and spiritual foundations through education.

The urgency of this study in the field of early childhood education lies in the critical role of teachers in implementing the STEAM learning

approach (Science, Technology, Engineering, Arts, and Mathematics), which is capable of developing various 21st-century skills in children, such as critical thinking, creativity, communication, and collaboration. Considering the still limited understanding and readiness of early childhood teachers in optimally integrating this approach, as well as the lack of facilities, infrastructure, and innovation in STEAM-based educational play, this study is highly needed as an effort to strengthen teacher capacity, enrich learning strategies, and encourage supportive policies. This also responds to educational challenges in the Industrial Revolution 4.0 era by providing a strong foundation for curriculum development and more relevant and applicable teacher training at the early childhood education level.

Methods

This study was conducted using the Systematic Literature Review (SLR) method. This research method involves identifying, critically evaluating, synthesizing, and summarizing relevant research findings related to a particular topic or research question (Putri et al., 2025). Through this method, the researchers systematically reviewed and identified journal articles by following predetermined stages at each step of the process (Huda et al., 2024).

The stages undertaken included: (1) identifying the research topic and searching for relevant studies, (2) screening documents to identify significant studies, (3) evaluating the eligibility of the selected studies, and (4) compiling the research findings through processes of analysis,

synthesis, and description (Kurniawati et al., 2024). Data were collected by searching for journal articles obtained through Google Scholar. A total of 15 national journal articles published between 2021 and 2025 were collected and selected based on the established criteria and research objectives.

During the review process, the selected articles were analyzed using predetermined keywords, namely: (1) author(s) and year of publication, (2) title, and (3) research findings. The results were then organized into tables and grouped according to the research questions. The final stage involved drawing conclusions based on the results of the analysis from all stages of the review process.

Results and Discussion

This section presents and discusses the results of the Systematic Literature Review concerning the role of teachers in implementing STEAM learning in early childhood education. The analysis is based on 15 national journal articles published between 2021 and 2025. The findings are organized in the form of a summary table followed by a comprehensive narrative discussion to explain patterns, challenges, and implications related to teachers' roles in STEAM-based learning for young children.

Table 1. The Role of Teachers in Implementing STEAM Learning in Early Childhood Education: A Systematic Literature Review

Author(s)	Journal	Title	Findings

Riski Wulan Rachmandani, Perdana Afif Luthfy, Muniroh Munawar (2025)	Jurnal Smart PAUD	The Role of Teachers in Implementing STEAM-Based Learning in Early Childhood Education	Teachers play a crucial role in the implementation of STEAM-based learning in early childhood education. They act as facilitators and mediators by providing tools and materials, guiding children in project planning, encouraging collaboration, and facilitating reflection after activities. Through STEAM

			learning, teachers are able to enhance children's critical thinking, creativity, and collaboration skills
Qonita, E. H. Mulyana, A. Loita, I. Anggraeni, S. A. Z. Sakinah, N. S. Sopiah (2023)	Magelaran: Jurnal Pendidikan Seni	Teachers' Perceptions of STEAM Learning at TK Labschool UPI Tasikmalaya	Teachers' perceptions of STEAM implementation are still not fully aligned with the integrative STEAM concept that emphasizes 21st-century skills such as creativity, critical thinking, communication,

			and collaboration. Limited innovation in learning game design, inadequate facilities, and insufficient understanding of STEAM concepts were identified. Solutions included STEAM-based game innovations such as robotic for hand and foot, windmill bubbles, and cardboard shooting games.

Siti Hanifah, Euis Kurniati (2024)	Research in Early Childhood Education and Parenting	Exploring the Role of Early Childhood Teachers in Implementing STEAM Methods in the Merdeka Curriculum	Early childhood teachers play an important role in designing and implementing STEAM activities. Essential competencies include the ability to design creative activities, understand STEAM principles, and adapt to classroom challenges. Adequate skills and effective strategies improve children's

			engagement and learning outcomes.
Elok Firdaus Aprilia (2022)	Jurnal Penelitian Anak Usia Dini	Early Childhood Teachers' Strategies in Implementing STEAM Learning in Malang City	Teachers applied indirect, child-centered learning strategies in implementing STEAM. Children were given opportunities to explore ideas and creativity independently through learning approaches centered on the child.
Novi Marliani, Idha Isnaningrum	SAMBARA: Jurnal Pengabdian	The Use of STEAM in	Teacher readiness in

(2025)	Kepada Masyarakat	Early Childhood Education	conceptual understanding and technical skills strongly influences the success of STEAM learning. Teachers act as facilitators and mediators in accordance with Indonesian Law No. 14 of 2005. Limitations in materials and online access highlight the need for school policy support and collaboration with parents and

			communities.
Rabitah Hanum Hasibuan, Rizki Awaliyah, Nurhasnah (2023)	Jurnal Inovasi Penelitian dan Pengabdian Masyarakat	Mentoring Early Childhood Teacher Communities in Designing Literacy- and STEAM-Based Learning Outcomes	The mentoring program resulted in successful implementation stages, the production of literacy- and STEAM-based learning outcomes, improved teacher competence, and positive teacher responses reflected through high enthusiasm.
Aam Kurnia, Dindin Nasrudin (2022)	Jurnal Obsesi	Measuring the Effectiveness of STEAM–	The training was categorized as highly

		Loose Parts Training for Early Childhood Teachers	effective. Teachers who were pursuing undergraduate education demonstrated the highest mastery of STEAM concepts. The study provides a framework for evaluating teacher training effectiveness.
Novitawati, Chresty Anggreani, Sakerani (2022)	JCES	Technical Guidance on Designing STEAM Learning for Early Childhood Teachers	STEAM training improved teachers' knowledge and skills in designing STEAM-based learning, contributing to

			higher learning quality and optimal child development.
Siti Khaeratul Mukarramah, Hajrah (2023)	PELITA	STEAM as an Educational Technology Innovation in Industry 4.0	The utilization of creative spaces for project-based activities enables learners to develop competencies required in Industry 4.0. The inclusion of arts supports the development of creativity and innovation.
Hafidzah Nur Adzani, Nurul Kusuma Dewi, Vera Sholeha (2022)	Kumara Cendekia	The Relationship between Teachers' Pedagogical	A significant positive relationship was found

		Competence and STEAM Implementation	between pedagogical competence and STEAM implementation (sig. = 0.013; Pearson correlation = 0.446), indicating that higher pedagogical competence leads to better STEAM practices.
Berliany Nuragnia, Nadiroh, Herlina Usman (2021)	Jurnal Pendidikan dan Kebudayaan	STEAM Learning in Elementary Schools: Implementation and Challenges	Teachers implemented STEAM through student-centered, inquiry-based, and problem-based learning,

			supported by evaluation, reflection, collaboration, and integrated learning.
Indra Kurniawan, Rahman Abdillah, Andri Rahadyan (2021)	Indonesian Journal of Community Service	Socialization of STEAM Learning Methods in the K-13 Curriculum	The implementation of STEAM learning methods improved teachers' instructional abilities in classroom practice.
Johanes Juan Yutama Putra Ie, Natalia Rosa Keliat (2025)	JRIP	Novice Teachers vs. Senior Teachers in STEAM Implementation	Senior teachers demonstrated more mature instructional strategies, while novice teachers were

			more adaptive in using digital media. Both groups faced limitations in cross-disciplinary collaboration and parental involvement.
Ni Made Ayu Suryaningsih et al. (2025)	Aulad	STEAM Implementation and Early Childhood Literacy: A Systematic Literature Review	STEAM learning significantly strengthens early childhood literacy, creativity, collaboration, and environmental awareness.
Annisa Dwi Yuniar et al. (2024)	AKSIOMA	Teachers' Perceptions, Beliefs, and Readiness	Teachers' perceptions and beliefs

		toward STEM Implementation	improved after participating in professional development programs, resulting in higher confidence and readiness to implement STEM learning.

The findings indicate that teachers play a strategic role as facilitators in STEAM learning for early childhood education. Teachers are no longer positioned as the primary source of information but as facilitators who provide opportunities for children to explore, create, and actively construct knowledge. Teachers guide children in planning projects, encourage peer collaboration, and conduct reflective activities to strengthen understanding. This role is essential in fostering 21st-century skills such as critical thinking, creativity, communication, and collaboration (Munawar, 2025; Putra, 2025). Additionally, teachers' roles as mediators support the creation of inclusive and intellectually stimulating learning environments (Marliani, 2025).

However, teachers' understanding of STEAM concepts remains a significant challenge. Many teachers have not yet integrated all STEAM

components comprehensively, particularly technology and scientific reasoning processes. This limitation is largely due to insufficient training opportunities and limited practical experience (Mulyana, 2023). Empirical evidence also shows a significant relationship between teachers' pedagogical competence and the effectiveness of STEAM implementation, indicating that higher pedagogical competence leads to better classroom practices (Adzani et al., 2024).

In practice, STEAM implementation in early childhood education generally adopts indirect, child-centered learning strategies. Teachers provide flexibility for children to explore ideas independently, which enhances curiosity and creativity in responding to phenomena in their immediate environment (Aprilia, 2022). Within the Merdeka Curriculum framework, teachers are expected to design STEAM activities that are adaptive, creative, and responsive to children's needs and contextual learning challenges (Kurniati, 2024).

Despite its benefits, STEAM implementation still faces several obstacles, including limited facilities and infrastructure, insufficient innovation in educational game design, and incomplete teacher understanding of STEAM concepts (Mulyana, 2023; Putra, 2025). Technical constraints such as limited internet access and restricted availability of digital learning resources further hinder effective STEAM learning (Marliani, 2025).

Various efforts have been made to overcome these challenges, including the development of STEAM-based educational games using

simple and locally available materials, such as robotic for hand and foot, windmill bubbles, and cardboard shooting games (Mulyana, 2023). Continuous teacher training and mentoring have also been shown to significantly enhance teachers' understanding and application of STEAM in classroom settings (Hasibuan et al., 2023; Suryaningsih, 2025).

Overall, STEAM learning has been proven to improve children's developmental outcomes, particularly in creativity, critical thinking, and collaboration. Teachers who have participated in STEAM training demonstrate improved mastery of content and more effective classroom implementation (Kurnia, 2022; Kurniawan et al., 2021). Proper STEAM implementation contributes to meaningful, contextual learning experiences that align with the developmental characteristics of early childhood learners (Anggreani, 2022).

Conclusion

Based on the results of the literature review, it can be concluded that the successful implementation of STEAM learning in early childhood education is highly dependent on the active role and competence of teachers as facilitators and mediators. Teachers who possess a strong understanding of STEAM concepts and are able to design creative learning activities have been proven to enhance children's critical thinking, creativity, and collaboration skills. These competencies are essential in preparing children to face the challenges of the 21st century.

However, several challenges remain in the implementation of

STEAM learning, including teachers' limited understanding of integrative STEAM concepts, inadequate facilities and infrastructure, and the lack of optimal integration of Islamic values, particularly hadith, in learning activities. These challenges indicate that STEAM implementation in early childhood education has not yet been fully maximized in a holistic and value-based manner.

Therefore, efforts to strengthen teacher capacity through continuous professional training, innovation in learning strategies, and policy support are urgently needed. Collaboration among schools, policymakers, parents, and the wider community is also essential to provide adequate learning resources and create a supportive learning environment. The integration of STEAM learning with values derived from hadith is expected to contribute to the development of a generation that is not only intellectually competent but also possesses strong moral character from an early age.

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