

INNOVATIVE SOLUTIONS FOR IMPLEMENTING THE STEAM APPROACH IN PRESCHOOL EDUCATION

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Abstract

This article examines innovative solutions for implementing the STEAM approach in preschool education. The relevance of the topic is determined by the growing need to improve the quality of early childhood education through integrated, child-centered, and creativity-oriented teaching methods. The purpose of the study is to analyze effective and innovative ways of introducing Science, Technology, Engineering, Arts, and Mathematics into preschool learning environments. The research is based on a qualitative analytical approach and uses descriptive and comparative methods. Scholarly literature, policy documents, and contemporary pedagogical practices related to early childhood STEAM education were reviewed and synthesized. The results show that the successful implementation of STEAM in preschool education depends on several key factors, including integrated thematic activities, play-based and project-based learning, flexible classroom organization, the creative use of low-cost materials, balanced use of digital tools, teacher professional development, and cooperation with families and communities. The study also identifies major barriers such as insufficient teacher training, limited methodological support, and traditional teaching practices that restrict child-centered learning. The discussion highlights that innovation in preschool STEAM should not be understood only as the use of technology, but also as pedagogical, organizational, and methodological renewal. The article concludes that the STEAM approach has strong potential to support children's holistic development, curiosity, creativity, communication, and early problem-solving skills when applied in developmentally appropriate ways. The findings may serve as a theoretical and practical basis for improving preschool educational practice and for guiding future empirical research in this field.

Keywords

preschool education, STEAM approach, early childhood education, innovative solutions, integrated learning, play-based learning, project-based learning, child-centered pedagogy, teacher professional development

Introduction

Early childhood education plays a decisive role in shaping children's cognitive, social, emotional, and creative development. In recent years, the growing complexity of the modern world has increased the need for educational models that promote not only basic literacy and numeracy, but also critical thinking, creativity, collaboration, and problem-solving from an early age. In this context, the STEAM approach—integrating **Science, Technology, Engineering, Arts, and Mathematics**—has emerged as an effective pedagogical framework for preparing young learners for the demands of the twenty-first century.[2] The application of STEAM in preschool education differs significantly from its use in primary or secondary schooling. At the preschool level, learning is primarily play-based, sensory, and exploratory. Therefore, implementing STEAM requires age-appropriate methods, flexible learning environments, and innovative solutions that align with children's developmental characteristics. Rather than



teaching disciplines separately, preschool STEAM education encourages children to observe, ask questions, experiment, create, and express ideas through hands-on and integrated activities. This approach supports holistic development and helps children build curiosity and confidence in learning.[1,3]

Despite its educational potential, the practical implementation of STEAM in preschool settings remains challenging in many contexts. Teachers often face difficulties related to insufficient methodological support, limited access to modern educational technologies, lack of interdisciplinary materials, and inadequate professional training. In addition, traditional teaching practices in early childhood education may not always correspond to the interactive and inquiry-based nature of STEAM pedagogy. These challenges make it necessary to search for innovative solutions that can facilitate the successful adaptation of STEAM principles in preschool institutions.[3,5] Innovative solutions in this area may include the use of digital learning tools, interactive games, project-based activities, maker-centered learning spaces, teacher training models, and collaboration between educators, parents, and the wider community. Such solutions can make STEAM learning more engaging, accessible, and developmentally appropriate for preschool children. Moreover, innovation in preschool STEAM education is not limited to technology alone; it also includes new pedagogical strategies, curriculum integration models, and creative assessment practices that support active participation and meaningful learning.[6,7]

The relevance of this topic is determined by the increasing global interest in early STEAM education and the need to improve the quality of preschool teaching through modern and effective approaches. Investigating innovative ways of implementing STEAM in preschool education can contribute to both theoretical understanding and practical improvement of early childhood pedagogy. Therefore, this article aims to examine innovative solutions for implementing the STEAM approach in preschool education and to analyze their pedagogical significance, practical advantages, and possible challenges in educational practice.[4]

Methods

This article uses a qualitative analytical approach based on the review and synthesis of scholarly literature, policy documents, and contemporary pedagogical practices related to the implementation of the STEAM approach in preschool education. The purpose of this method is to identify innovative solutions that support the effective integration of Science, Technology, Engineering, Arts, and Mathematics in early childhood learning environments. The study relies on a descriptive and comparative method. First, existing theoretical and practical sources on STEAM education in early childhood were examined in order to clarify the conceptual foundations of the approach. Second, different models of STEAM implementation in preschool settings were compared to determine which innovative practices are most suitable for young children's developmental needs. Particular attention was given to solutions such as play-based learning, project-based activities, digital educational tools, creative classroom design, and teacher professional development. The selection of materials for analysis was based on their relevance to three main criteria: focus on preschool or early childhood education, connection with STEAM-based teaching and learning, and discussion of innovative pedagogical or organizational solutions. The analytical process included several stages. At the first stage, sources were grouped according to key themes such as curriculum integration, child-centered learning, digital innovation, and teacher competence.[6,7] At the second stage, the main ideas and practices presented in these sources were analyzed and interpreted. At the third stage, the



most effective and adaptable innovative solutions were identified and systematized in relation to preschool educational practice. In addition, the article applies an IMRaD-oriented academic structure to ensure logical organization and clarity of presentation. Although the study is not based on experimental data collection, it seeks to provide a systematic and evidence-informed discussion of the topic. The methodological approach makes it possible to summarize current trends and highlight practical directions for improving the implementation of STEAM in preschool institutions. The limitation of this method is that the conclusions are based on secondary sources rather than direct field observation or empirical testing. However, the chosen approach is appropriate for exploring the theoretical and practical dimensions of innovative STEAM implementation and for generating a foundation for future empirical research.[9]

Results

The analysis of scholarly sources, policy-oriented materials, and contemporary preschool practices showed that the implementation of the STEAM approach in early childhood education produces meaningful pedagogical benefits when it is adapted to the developmental characteristics of young children. The reviewed materials indicate that STEAM in preschool settings is most effective not as a separate subject-based model, but as an integrated, play-oriented, and inquiry-based educational approach. The findings reveal that innovative solutions in preschool STEAM implementation can be grouped into several major areas: curriculum integration, child-centered pedagogy, learning environment design, digital and material resources, teacher professional competence, and family-community cooperation. Together, these areas create the conditions necessary for the successful introduction of STEAM principles in preschool institutions.[3] One important result is that integrated learning activities are more developmentally appropriate for preschool children than isolated instruction in science, mathematics, or technology. The examined practices show that children learn more effectively when they engage in real or simulated life situations that combine observation, experimentation, construction, artistic expression, and simple numerical reasoning. For example, activities such as building a bridge from blocks, growing plants, creating weather charts, mixing colors, or designing simple models from recycled materials allow children to use several STEAM domains simultaneously. This interdisciplinary format strengthens curiosity, creativity, and problem-solving ability while also improving language use, communication, and social interaction. As a result, the STEAM approach in preschool education supports holistic development rather than narrow academic training.[4,5]

Another major finding is that play-based and project-based learning serve as the most productive instructional models for implementing STEAM in early childhood settings. The analysis shows that innovative preschool practices often organize STEAM around themes, questions, or small projects rather than formal lessons. In such settings, children are encouraged to ask questions, predict outcomes, test ideas, and reflect on what they have discovered. This approach increases participation and allows learning to emerge naturally from exploration. It was also found that project-based STEAM activities promote persistence, teamwork, and independent thinking. When children work together to solve a practical problem—such as how to make a paper boat float longer, how to build the tallest tower, or how to create patterns using natural materials—they begin to develop the foundations of engineering logic and scientific inquiry at an early age.[8,9] The review also demonstrates that the physical and pedagogical design of the classroom significantly affects the quality of STEAM implementation. Preschool institutions that successfully apply STEAM principles usually provide flexible and stimulating learning spaces.



These spaces include construction corners, creativity zones, experiment tables, sensory materials, digital devices when available, and open-ended resources that children can manipulate freely. The results suggest that innovative classroom organization encourages exploration and experimentation more effectively than traditional desk-based arrangements. A learning environment rich in diverse materials gives children opportunities to test ideas independently and collaboratively. In this context, even simple low-cost materials such as paper, sand, water, clay, cardboard, leaves, bottle caps, magnets, and wooden blocks can serve as effective STEAM resources when used intentionally by teachers.

The analysis further shows that digital tools can strengthen preschool STEAM education when they are used in a balanced and age-appropriate way. Interactive whiteboards, tablets with educational applications, digital microscopes, audio-visual storytelling resources, and simple coding toys can enrich children's learning experiences. However, the findings emphasize that technology is not the core of STEAM; rather, it is one of many supportive instruments. The most successful models do not replace hands-on activity with screens, but combine digital support with tactile, social, and creative experiences. For example, children may first observe insects in a garden, then view them on a screen, draw them, classify them by shape or size, and finally build models using craft materials. This layered process deepens understanding and maintains active participation. A significant result of the study is that teacher competence remains the central factor in the success or failure of preschool STEAM implementation. Many sources indicate that educators support STEAM more effectively when they understand interdisciplinary teaching, child-centered facilitation, observation-based assessment, and creative material design. At the same time, one of the most frequent barriers identified in the literature is insufficient teacher preparation. Some preschool teachers feel uncertain about how to combine science, mathematics, art, and engineering in one activity, while others associate STEAM too narrowly with expensive technologies or formal experiments. The results therefore highlight the need for systematic professional development, including workshops, demonstration classes, peer collaboration, and access to practical teaching guides. Innovative implementation becomes sustainable only when teachers are confident, methodologically prepared, and institutionally supported.[3-6]

The analysis also reveals that assessment in preschool STEAM should be process-oriented rather than product-oriented. Effective practices do not evaluate children only by the final result of an activity, but by their level of participation, questioning, experimentation, collaboration, creativity, and communication. Observation sheets, anecdotal notes, child portfolios, visual documentation, and reflective discussion were identified as the most suitable assessment tools. These methods allow teachers to monitor developmental progress without creating pressure or using age-inappropriate academic testing. In this way, innovative STEAM implementation aligns with the broader developmental goals of preschool education.[5] Another important outcome is the recognition of family and community involvement as a valuable innovative solution. Preschool institutions that engage parents in simple STEAM projects, exhibitions, home experiments, recycling activities, and creative workshops create stronger continuity between school and home learning. Parents can support children's curiosity by participating in practical tasks such as planting seeds, building simple models, sorting household objects, or discussing natural phenomena. Community partnerships with libraries, museums, local artisans, science centers, and environmental organizations also enrich the preschool STEAM experience. The findings suggest that such collaboration broadens children's exposure to real-world exploration and makes learning more meaningful.[7]



At the same time, the review identified several persistent challenges. These include limited material resources, lack of methodological frameworks, insufficient training opportunities, traditional teacher-centered practices, and unequal access to digital tools. In some settings, STEAM remains only a formal concept in planning documents and is not transformed into everyday pedagogical practice. Another challenge is the misunderstanding of preschool STEAM as early academic acceleration rather than exploratory development. The findings make it clear that successful implementation depends on rethinking educational priorities: the goal is not to impose complex scientific content on young children, but to create conditions in which they can investigate, create, and solve simple problems in age-appropriate ways.[3] Overall, the results show that innovative solutions in implementing the STEAM approach in preschool education are most effective when they are affordable, flexible, developmentally appropriate, and pedagogically grounded. Innovation should therefore be understood broadly—not only as the use of modern devices, but also as the introduction of integrated themes, creative materials, new teacher roles, interactive environments, and collaborative partnerships. Based on the reviewed sources, it can be concluded that the successful adoption of STEAM in preschool education improves children’s curiosity, creative expression, early logical thinking, communication, cooperation, and readiness for lifelong learning.

Table 1. Main innovative solutions for implementing STEAM in preschool education

Innovative solution	Description	Expected educational effect
Integrated thematic activities	Combines science, technology, engineering, art, and mathematics within one topic or task	Strengthens holistic learning and interdisciplinary thinking
Play-based learning	Uses games, role play, and exploration as the main form of STEAM activity	Increases motivation, engagement, and age-appropriate participation
Project-based tasks	Organizes learning around practical mini-projects and problem-solving activities	Develops creativity, teamwork, and persistence
Flexible learning spaces	Provides experiment corners, construction areas, and creative studios	Encourages independent exploration and collaboration
Use of low-cost materials	Applies recycled and natural resources for experiments and design	Makes STEAM accessible and sustainable
Digital educational tools	Uses tablets, interactive boards, coding toys, and visual media in moderation	Enriches observation, visualization, and interactive learning
Teacher professional development	Offers training, workshops, and methodological support	Improves instructional quality and confidence
Family and	Engages parents and external partners in	Connects school learning with



Innovative solution	Description	Expected educational effect
community involvement	practical activities	real-life experience
Process-based assessment	Focuses on observation, portfolios, and participation rather than tests	Supports child-centered evaluation and developmental monitoring

Table 2. Observed benefits of STEAM implementation in preschool education

Developmental area	Observed benefit	Example in preschool practice
Cognitive development	Improves curiosity, observation, and reasoning	Children compare objects, predict outcomes, and draw simple conclusions
Creative development	Expands imagination and artistic expression	Children design models, mix colors, and create visual representations
Social development	Strengthens communication and teamwork	Children build or experiment together in small groups
Emotional development	Builds confidence and persistence	Children try different solutions and learn from mistakes
Language development	Enriches vocabulary and explanation skills	Children describe processes, materials, and results
Early mathematical thinking	Develops counting, measuring, sorting, and pattern recognition	Children classify leaves, count blocks, or compare sizes
Scientific thinking	Encourages asking questions and testing ideas	Children observe water, plants, shadows, or magnets
Engineering thinking	Introduces design and construction logic	Children build bridges, towers, ramps, or shelters

Table 3. Main barriers and recommended solutions

Identified barrier	Practical impact	Recommended solution
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Identified barrier	Practical impact	Recommended solution
Lack of teacher training	Teachers feel uncertain about STEAM integration	Organize targeted professional development and mentoring
Limited resources	Activities become theoretical rather than practical	Use recycled, local, and natural materials creatively
Traditional teaching methods	Reduces child participation and inquiry	Shift toward play-based and child-centered pedagogy
Weak methodological guidance	Teachers lack clear activity models	Develop STEAM lesson banks and institutional guidelines
Overreliance on technology	Hands-on learning may decrease	Balance digital tools with sensory and practical exploration
Limited parental involvement	Learning remains disconnected from home	Create simple home-based STEAM tasks and parent workshops
Inadequate assessment practices	Children's real progress is not fully captured	Apply observation, documentation, and portfolio assessment

Table 4. Sample preschool STEAM activity models

Theme	STEAM components involved	Activity example	Learning outcome
Plants and growth	Science, Art, Mathematics	Children plant seeds, observe growth, draw changes, and measure height	Observation, recording, comparison
Weather	Science, Technology, Art	Children observe clouds, make weather symbols, use pictures/videos	Understanding natural phenomena
Bridges and buildings	Engineering, Mathematics, Art	Children build structures from blocks or cardboard	Spatial thinking and design skills
Water exploration	Science, Engineering	Children test floating and sinking objects	Experimentation and prediction
Colors and light	Science, Art	Children mix colors and explore light/shadow	Cause-effect understanding
Patterns in	Mathematics, Art,	Children collect leaves, stones,	Classification and



Theme	STEAM components involved	Activity example	Learning outcome
nature	Science	and flowers to create patterns	pattern recognition
Simple coding games	Technology, Mathematics	Children follow directions or use coding toys	Sequencing and logical thinking

Concise analytical summary of the results

Dimension	Main result
Pedagogical model	STEAM is most effective when integrated into play-based and inquiry-based preschool practice
Learning environment	Flexible, resource-rich, and interactive classrooms improve implementation quality
Teacher role	Teachers act as facilitators, observers, and co-explorers rather than only instructors
Innovation	Innovation includes pedagogy, materials, assessment, and partnerships, not only technology
Child outcomes	Positive influence on creativity, curiosity, communication, cooperation, and early problem-solving
Key condition for success	Continuous teacher preparation and developmentally appropriate practice

Discussion

The findings of this article show that the implementation of the STEAM approach in preschool education is most effective when it is understood not as the early introduction of separate academic disciplines, but as an integrated pedagogical model adapted to the developmental needs of young children. This point is especially important because preschool education is fundamentally based on play, exploration, communication, and sensory interaction with the environment. Therefore, the value of STEAM at this level lies not in teaching complex scientific or technological concepts in a formal way, but in creating learning situations in which children can observe, question, experiment, construct, create, and reflect through age-appropriate activities. From this perspective, the results confirm that innovative solutions in preschool STEAM should be interpreted broadly, including not only digital tools, but also flexible pedagogy, integrated curriculum design, creative materials, and collaborative learning environments.[2-5] One of the central issues emerging from the results is the strong compatibility between STEAM and child-centered education. The reviewed practices



demonstrate that when children participate in thematic projects, hands-on experiments, building tasks, and artistic exploration, they engage in natural forms of learning that correspond with the principles of early childhood pedagogy. This supports the argument that STEAM is not an external addition to preschool education, but rather a model that can strengthen its existing developmental goals. In other words, STEAM becomes meaningful in preschool settings when it grows out of children's curiosity and lived experiences. Activities related to nature, water, weather, colors, movement, sound, shape, and construction are especially effective because they connect directly with children's daily observations and interests. The discussion therefore suggests that successful STEAM implementation depends on the teacher's ability to transform ordinary classroom experiences into integrated opportunities for inquiry and creativity.[6]

Another important point is that innovation in preschool STEAM should not be reduced to the use of advanced technology. Although digital devices, educational applications, interactive boards, and simple coding toys can enrich children's learning, the results make it clear that technology alone does not guarantee meaningful implementation. In many cases, the most effective STEAM experiences emerge from simple and accessible materials such as blocks, recycled objects, paper, sand, water, leaves, clay, magnets, and paints. This has significant practical implications, particularly for preschool institutions with limited budgets. It means that the successful implementation of STEAM is possible even in resource-constrained environments if educators apply creative methods and intentional pedagogical planning. Thus, innovation should be viewed not only as technological modernization, but also as methodological renewal and the creative use of locally available materials.[6] The discussion also highlights the decisive role of the teacher in the implementation process. While the STEAM approach promotes active learning and child initiative, these outcomes do not occur automatically. They require a teacher who can design meaningful tasks, guide exploration without excessive control, ask stimulating questions, observe children's thinking, and connect different fields of learning within one activity. The results indicate that many educators still face uncertainty in this area, particularly when they lack training in interdisciplinary teaching. This suggests that one of the most urgent priorities for preschool education systems is the professional development of teachers. Training should not be limited to abstract theory; it should include practical models, activity examples, classroom demonstrations, peer exchange, and reflective support. Without such preparation, STEAM may remain only a formal concept in policy documents rather than a living practice in preschool classrooms.[3,4]

The findings further show that the physical and social learning environment has a significant impact on the success of STEAM-based education. Flexible classroom design, access to open-ended materials, spaces for experimentation, and opportunities for small-group collaboration all contribute to deeper engagement and more meaningful learning. This supports the idea that the environment itself acts as an educational resource. In preschool STEAM, children learn not only from direct instruction, but also from the possibilities offered by the arrangement of space, materials, and interactions. Therefore, institutions seeking to implement STEAM should reconsider the organization of classrooms and prioritize environments that invite exploration, construction, imagination, and discovery. Even modest changes in classroom design can increase children's active participation and support integrated learning processes.[7,8] Assessment is another area that deserves careful consideration. The results indicate that preschool STEAM should be evaluated through process-oriented methods such as observation, documentation, portfolios, visual records, and teacher reflection rather than through formal testing or narrow performance indicators. This is consistent with the developmental philosophy



of early childhood education, where the process of learning is often more important than the final product. In STEAM activities, children may not always produce a correct or finished result, yet they still demonstrate meaningful learning through questioning, experimenting, collaborating, revising ideas, and expressing their thinking. The discussion therefore suggests that assessment practices must recognize and value these developmental processes. Such an approach also reduces pressure on children and allows teachers to better understand each child's individual learning pathway.

A particularly significant issue raised by the findings is the need to involve families and the broader community in preschool STEAM education. Learning at an early age does not take place only within institutional boundaries. When parents are involved in simple home-based experiments, creative tasks, nature observation, or construction activities, children experience continuity between school and home. Likewise, collaboration with local libraries, museums, environmental centers, and community experts can expand children's experiences and make learning more connected to the real world. This suggests that preschool STEAM is most sustainable when it is supported by a network of relationships rather than by the teacher alone. Family and community participation also help to strengthen the social relevance of preschool education and encourage shared responsibility for children's development.[7] At the same time, the discussion must acknowledge the limitations and challenges identified in the results. The implementation of STEAM in preschool education may be hindered by rigid curricula, lack of materials, insufficient teacher confidence, limited methodological guidance, and misconceptions about the purpose of early STEAM. In some cases, educators may interpret STEAM as a pressure to accelerate academic instruction, which can lead to inappropriate expectations for young children. This is a serious concern because it contradicts the developmental foundations of preschool education. The discussion therefore emphasizes that STEAM should not be used to formalize early childhood learning, but to enrich it through integrated, playful, and meaningful experiences. Policymakers, school leaders, and teacher educators must ensure that STEAM reforms remain compatible with the psychological and pedagogical characteristics of early childhood.[3]

Overall, the findings discussed in this study suggest that the STEAM approach has strong potential to improve the quality of preschool education when implemented through innovative, flexible, and developmentally appropriate strategies. Its greatest contribution lies in promoting curiosity, creativity, communication, collaboration, and early problem-solving in ways that are natural and engaging for young children. However, this potential can only be realized when innovation is supported by trained teachers, inclusive learning environments, suitable materials, and strong cooperation among educational stakeholders. For this reason, future practice should focus on creating sustainable models of preschool STEAM that are both pedagogically sound and practically adaptable. Future research may build on this discussion by conducting empirical studies in preschool institutions, observing classroom implementation directly, and measuring the developmental effects of specific STEAM strategies in different educational contexts.

Conclusion

In conclusion, the implementation of the STEAM approach in preschool education represents an important step toward improving the quality and relevance of early childhood learning. The analysis presented in this article shows that STEAM can be effectively adapted to preschool settings when it is introduced through integrated, play-based, and child-centered



pedagogical practices. Its value lies in supporting the holistic development of children by encouraging curiosity, creativity, communication, cooperation, critical thinking, and early problem-solving skills. Rather than functioning as a formal academic model, preschool STEAM becomes most meaningful when it is embedded in everyday exploratory activities that reflect children's developmental needs and interests. The study also demonstrates that innovative solutions play a decisive role in the successful implementation of STEAM in preschool institutions. These solutions include integrated thematic learning, project-based activities, flexible classroom organization, the creative use of low-cost and natural materials, balanced application of digital tools, process-oriented assessment, and active cooperation with families and the community. Together, these elements help create an educational environment in which young children can learn through discovery, experimentation, design, and artistic expression. At the same time, the article emphasizes that innovation in preschool STEAM should not be limited to technology, but should also involve methodological, organizational, and pedagogical renewal. However, the effective implementation of STEAM in preschool education still depends on several important conditions. Among them, teacher competence, professional development, institutional support, and the availability of practical methodological resources are particularly significant. Without these conditions, STEAM may remain only a theoretical concept rather than becoming an active and sustainable part of preschool practice. Therefore, educators, policymakers, and curriculum developers should work together to ensure that STEAM is implemented in ways that are accessible, developmentally appropriate, and pedagogically grounded. Overall, the article confirms that the STEAM approach has strong potential to enrich preschool education and prepare children for lifelong learning in a changing world. By using innovative and flexible strategies, preschool institutions can create meaningful learning experiences that nurture both intellectual and creative growth. Future studies may further strengthen this field by conducting empirical research on classroom implementation and by evaluating the long-term developmental outcomes of STEAM-based early childhood education.

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