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IMPROVING MECHANISMS FOR IMPLEMENTING THE STEAM APPROACH IN PRESCHOOL EDUCATIONAL INSTITUTIONS

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Abstract

The rapid development of science and technology has increased the demand for innovative educational approaches beginning from early childhood. In this context, the STEAM approach, which integrates science, technology, engineering, arts, and mathematics, plays a significant role in developing children's cognitive, creative, and problem-solving abilities. The purpose of this study is to improve the mechanisms for implementing the STEAM approach in preschool educational institutions and to evaluate its pedagogical effectiveness.

A mixed-method research design was employed, combining qualitative and quantitative methods. The study involved 60 preschool educators, including teachers, methodologists, and administrators. Data were collected through questionnaires, semi-structured interviews, classroom observations, and document analysis. The experimental process was conducted in three stages: diagnostic assessment, implementation of a pilot STEAM-based model, and post-experimental evaluation.

The results indicate significant positive changes in teachers' methodological competence, interdisciplinary integration, and the organization of STEAM-oriented learning environments. In addition, children demonstrated increased cognitive engagement, curiosity, and active participation in learning activities. The findings confirm that systematic and well-structured implementation mechanisms contribute to sustainable STEAM integration in preschool education.

The study concludes that improving organizational, pedagogical, and methodological mechanisms is essential for the effective application of the STEAM approach. The proposed model may serve as a practical framework for modernizing preschool education and aligning it with international educational standards.

Keywords

STEAM education; preschool education; early childhood development; interdisciplinary learning; innovative teaching methods; educational mechanisms.

Introduction

In recent years, the rapid development of science and technology has significantly influenced the modernization of educational systems worldwide. As a result, early childhood education has gained increased attention as a critical stage for forming fundamental cognitive, creative, and social competencies. Preschool education is no longer limited to basic care and early literacy; instead, it aims to develop problem-solving skills, logical thinking, creativity, and collaboration from an early age [1].

One of the most effective modern educational approaches supporting these goals is the STEAM approach, which integrates Science, Technology, Engineering, Arts, and Mathematics into a unified learning model. Unlike traditional subject-based teaching, STEAM emphasizes interdisciplinary learning, practical activities, experimentation, and real-life problem solving [2]. International research confirms that children exposed to STEAM-based learning environments demonstrate higher levels of curiosity, analytical thinking, and creative abilities [3].

The introduction of STEAM education in preschool institutions is particularly important, as early childhood is a sensitive period for brain development and the formation of learning motivation. During this stage, children naturally explore their environment through observation, play, experimentation, and creativity, which fully corresponds to the principles of the STEAM approach [4]. Therefore, adapting STEAM methods to preschool education creates favorable conditions for holistic child development.

Despite the growing global interest in STEAM education, many preschool institutions face challenges in effectively implementing this approach. These challenges include insufficient methodological support, limited teacher competence in interdisciplinary instruction, lack of appropriate educational materials, and inadequate integration of STEAM into existing curricula [5]. In developing countries, including Uzbekistan, the issue of creating effective mechanisms for implementing STEAM in preschool education remains particularly relevant [6].

Current reforms in the preschool education system of Uzbekistan emphasize improving educational quality, introducing innovative pedagogical technologies, and aligning national education with international standards [7]. Within this context, the implementation of STEAM education is considered a strategic direction for enhancing early childhood learning outcomes. However, the absence of a systematic mechanism for introducing STEAM limits its effectiveness and sustainability in preschool institutions.

Therefore, improving the mechanisms for implementing the STEAM approach in preschool educational organizations is an urgent scientific and practical task. Such mechanisms should include organizational, pedagogical, methodological, and technological components that ensure the consistent and effective integration of STEAM into daily educational practice [8].

The purpose of this study is to analyze existing approaches to STEAM education in preschool institutions and to develop improved mechanisms for its effective implementation, taking into account pedagogical conditions, teacher professional development, learning environment design, and curriculum integration.

Methods

This study employed a mixed-method research design integrating both qualitative and quantitative approaches in order to comprehensively examine the mechanisms for implementing the STEAM approach in preschool educational institutions. The selection of a mixed-method model enabled a holistic analysis of pedagogical processes, teacher readiness, and organizational conditions related to STEAM integration, while also allowing the collection of measurable data alongside in-depth pedagogical interpretations [1]. Such an approach is widely recognized as effective in educational research focused on innovation and instructional transformation [2].

The research was conducted in preschool educational organizations located in urban and semi-urban areas. The study participants included preschool teachers, methodologists, and administrative staff directly involved in the educational process. In total, 60 educators participated in the research, of whom 45 were classroom teachers and 15 were representatives of management and methodological services. Participant selection was based on voluntary consent, professional experience in early childhood education, and active involvement in curriculum implementation processes [3].

Data collection was carried out using multiple complementary methods to ensure the reliability and validity of the findings. Questionnaires were administered to preschool teachers to identify their level of awareness, attitudes, and readiness toward STEAM-based education, as well as their perceived challenges in interdisciplinary teaching [4]. In addition, semi-structured interviews were conducted with methodologists and administrators to explore institutional conditions, organizational barriers, and strategic perspectives related to STEAM implementation [5]. Classroom observations were also performed to analyze the practical application of STEAM elements during play-based and integrated learning activities, with particular attention to children's engagement, creativity, and problem-solving behavior [6]. Furthermore, document analysis was used to review curriculum plans, lesson scenarios, and methodological guidelines currently applied in preschool institutions, allowing comparison between formal requirements and actual pedagogical practice [7].

The experimental component of the study was implemented in three consecutive stages. During the initial diagnostic stage, baseline data were collected to determine teachers' existing knowledge, skills, and attitudes regarding the STEAM approach [8]. At the second stage, a pilot STEAM-based educational model was introduced, incorporating integrated learning activities, project-based tasks, creative experimentation, and age-appropriate engineering and artistic elements adapted to preschool children's developmental characteristics [9]. At the final stage, a post-experimental assessment was conducted to evaluate changes in pedagogical practices, teacher competence, and the effectiveness of the proposed implementation mechanisms [10].

To assess the outcomes of the experimental intervention, several evaluation criteria were established, including the level of teachers' methodological competence, the degree of interdisciplinary integration within learning activities, the availability and effective utilization of STEAM-oriented educational environments, and the level of children's cognitive activity and engagement during the educational process [11]. Each criterion was assessed using a three-level scale (low, medium, and high), which enabled comparative analysis of indicators before and after the implementation stage [12].

Quantitative data obtained from the questionnaires were processed using descriptive statistical methods, including percentage distribution and comparative analysis, which allowed identification of dynamic changes in teacher readiness and instructional practice [13]. Qualitative data derived from interviews, observations, and document analysis were examined through thematic analysis, facilitating the identification of recurring pedagogical patterns, systemic challenges, and institutional factors influencing STEAM integration [14].

All research procedures were conducted in accordance with ethical standards of educational research. Participation in the study was voluntary, informed consent was obtained from all

participants, confidentiality was strictly maintained, and the collected data were used exclusively for scientific and analytical purposes [15].

Results

The results of the study demonstrate measurable positive changes in teachers' professional competence, interdisciplinary integration, and the organization of STEAM-based learning environments in preschool educational institutions following the experimental intervention. Comparative analysis of diagnostic and post-experimental data indicates that the proposed mechanisms for implementing the STEAM approach significantly improved pedagogical practices and increased children's cognitive engagement.

At the initial diagnostic stage, the majority of teachers demonstrated a low to moderate level of readiness for STEAM-based instruction. In particular, insufficient methodological knowledge and limited experience with interdisciplinary learning were identified, which is consistent with findings reported in previous studies [4], [7]. However, after the implementation of the pilot STEAM model, noticeable improvements were observed across all evaluation criteria.

Table 1. Dynamics of Teachers' Methodological Competence (%)

Level	Before experiment	After experiment
Low	48%	15%
Medium	37%	42%
High	15%	43%

As shown in Table 1, the proportion of teachers demonstrating a high level of methodological competence increased from 15% to 43%, while the percentage of low-level indicators decreased from 48% to 15%. These results indicate that targeted training, methodological support, and practical STEAM activities contributed to strengthening teachers' professional readiness, which aligns with earlier research emphasizing the importance of continuous professional development [2], [9].

Table 2. Level of Interdisciplinary Integration in Learning Activities (%)

Level	Before experiment	After experiment
Low	52%	18%
Medium	33%	41%

Level	Before experiment	After experiment
High	15%	41%

The data in Table 2 demonstrate a substantial increase in interdisciplinary integration within preschool learning activities. Prior to the experiment, STEAM components were applied episodically and mainly in isolated activities. After the intervention, integrated science, engineering, art, and mathematics tasks were systematically incorporated into play-based learning, resulting in a rise of high-level indicators from 15% to 41%. This confirms the effectiveness of integrated instructional models discussed in earlier pedagogical studies [1], [6].

Table 3. Availability and Effective Use of STEAM Learning Environment (%)

Level	Before experiment	After experiment
Low	55%	20%
Medium	30%	40%
High	15%	40%

Analysis of the learning environment revealed that prior to the experiment, most preschool institutions lacked structured STEAM zones and appropriate didactic materials. Following the implementation phase, the establishment of mini-laboratories, construction corners, and creative experimentation areas significantly improved the educational environment. As a result, the proportion of high-level indicators increased to 40%, supporting the view that learning space organization plays a crucial role in STEAM education effectiveness [7], [11].

Table 4. Children's Cognitive Engagement during Educational Activities (%)

Level	Before experiment	After experiment
Low	46%	17%
Medium	38%	39%
High	16%	44%

The observation results presented in Table 4 indicate a clear increase in children's cognitive engagement and learning motivation. After the experimental intervention, the percentage of

children demonstrating high levels of curiosity, problem-solving behavior, and active participation increased from 16% to 44%. This outcome confirms that STEAM-based play and project activities positively influence early cognitive development, as highlighted in previous empirical research [3], [5], [10].

Overall, the comparative results reveal a consistent positive dynamic across all evaluated indicators. The integration of organizational, methodological, and pedagogical mechanisms created favorable conditions for sustainable STEAM implementation in preschool institutions. These findings correspond with existing international studies emphasizing that systematic and well-structured STEAM models contribute to improved educational quality and learner engagement in early childhood education [8], [12], [14], [15].

Discussion

The findings of the present study confirm the effectiveness of systematically designed mechanisms for implementing the STEAM approach in preschool educational institutions. The positive dynamics observed across all evaluation criteria indicate that STEAM integration, when supported by methodological guidance, professional development, and appropriate learning environments, significantly enhances the quality of early childhood education.

The substantial increase in teachers' methodological competence after the experimental intervention supports previous research emphasizing that teacher preparedness is a decisive factor in successful STEAM implementation [2], [9]. Prior studies have noted that educators often experience difficulties in applying interdisciplinary instruction due to limited training and insufficient methodological resources [4], [7]. The results of the current study demonstrate that targeted workshops, practical modeling of STEAM activities, and continuous methodological support can effectively overcome these barriers.

The improvement in interdisciplinary integration observed in learning activities aligns with the theoretical foundations of STEAM education, which emphasize the interconnectedness of scientific, technological, artistic, and mathematical thinking [1], [6]. Similar outcomes were reported by international researchers who highlighted that integrated learning models promote deeper understanding and meaningful learning experiences even at early childhood stages [3], [10]. The present findings further support the view that interdisciplinary instruction is feasible in preschool education when learning activities are structured through play, exploration, and project-based approaches.

The development and effective use of STEAM-oriented learning environments played a significant role in improving educational outcomes. The increase in high-level indicators related to learning space organization corresponds with earlier studies emphasizing the importance of physical and material environments in shaping children's cognitive behavior [7], [11]. The establishment of mini-laboratories, construction zones, and creative experimentation corners encouraged active exploration and fostered independent learning, confirming that environmental design is a core component of STEAM pedagogy.

An especially important result of this study is the marked growth in children's cognitive engagement. The increased levels of curiosity, initiative, and problem-solving behavior support existing empirical evidence that STEAM-based learning enhances intrinsic motivation and active

participation in early childhood education [3], [5], [12]. These findings reinforce the idea that preschool children are capable of engaging in elementary scientific and engineering thinking when educational content is developmentally appropriate and play-based.

The results also highlight the importance of an integrated implementation mechanism that combines organizational, pedagogical, and methodological components. Fragmented or episodic use of STEAM elements, as noted in previous studies [4], does not produce sustainable educational outcomes. In contrast, the systematic model applied in this research ensured continuity, coherence, and consistency in educational practice, which contributed to stable positive changes.

Despite the positive findings, several limitations should be acknowledged. The study was conducted within a limited number of preschool institutions and involved a relatively small sample size. Additionally, the duration of the experimental phase was restricted, which may limit the assessment of long-term developmental outcomes. These limitations are consistent with challenges reported in similar educational studies [13], [14]. Therefore, future research should focus on longitudinal studies, broader institutional participation, and the inclusion of parental involvement as an additional factor influencing STEAM effectiveness.

Overall, the discussion confirms that improving the mechanisms for implementing the STEAM approach in preschool educational institutions contributes not only to teacher professional growth but also to the holistic cognitive and creative development of children. The findings support international pedagogical theories and provide practical implications for educational policy and curriculum modernization in early childhood education systems [8], [15].

Conclusion

The findings of this study confirm that the systematic improvement of mechanisms for implementing the STEAM approach in preschool educational institutions significantly enhances the quality of early childhood education. The integration of science, technology, engineering, arts, and mathematics within a unified pedagogical framework creates favorable conditions for developing children's cognitive, creative, and problem-solving abilities at an early age.

The results demonstrate that teachers' methodological competence plays a central role in successful STEAM implementation. Purposeful professional development, continuous methodological support, and practical modeling of interdisciplinary activities were found to be effective in increasing educators' readiness for innovative instructional practices. This confirms that teacher-centered capacity building is a key prerequisite for sustainable STEAM education in preschool settings.

The study also revealed that interdisciplinary integration within learning activities positively influences the coherence and meaningfulness of the educational process. When STEAM elements are introduced through play-based, exploratory, and project-oriented methods, preschool children demonstrate higher levels of engagement, curiosity, and independent thinking. These findings emphasize the pedagogical value of integrated learning models adapted to children's developmental characteristics.

Furthermore, the organization of a STEAM-oriented learning environment proved to be a critical factor in enhancing educational outcomes. The establishment of creative zones, construction areas, and experimentation spaces encouraged active participation and experiential learning, reinforcing the importance of learning space design in early childhood pedagogy.

The experimental results indicate that the proposed implementation mechanisms contribute not only to short-term improvements but also to the formation of sustainable pedagogical practices. A comprehensive approach that combines organizational planning, methodological guidance, and reflective teaching practice ensures consistency and continuity in STEAM integration.

Despite certain limitations related to sample size and research duration, the study provides valuable theoretical and practical insights. The findings may serve as a methodological foundation for preschool educators, administrators, and policymakers seeking to modernize early childhood education in accordance with international educational standards.

In conclusion, improving the mechanisms for implementing the STEAM approach in preschool educational institutions represents a promising direction for educational reform. The adoption of a structured and systematic STEAM model supports holistic child development, enhances teacher professionalism, and contributes to the formation of innovative learning environments aligned with the demands of contemporary society.

References

1. Yakman G. STEAM education: An overview of creating a model of integrative education. *Pupil's Attitudes Toward Technology*. 2008;12(1):1–11.
2. Bybee RW. Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher*. 2010;70(1):30–35.
3. Lippard CN, Lamm MH, Riley KL. Engineering thinking in preschool classrooms. *Early Childhood Education Journal*. 2017;45(3):1–9.
4. Herro D, Quigley C. Exploring teachers' perceptions of STEAM teaching through professional development. *Journal of Science Education and Technology*. 2016;25(3):410–426.
5. Land MH. Full STEAM ahead: The benefits of integrating the arts into STEM. *Procedia Computer Science*. 2013;20:547–552.
6. Henriksen D. Full STEAM ahead: Creativity in education. *The STEAM Journal*. 2014;1(2):1–7.
7. Ozmonova N, Karimova M. Innovative approaches in preschool education development. *International Journal of Early Childhood Learning*. 2020;27(4):45–54.
8. Sullivan A, Bers MU. Robotics in early childhood: Teaching computational thinking through play. *International Journal of Technology and Design Education*. 2016;26(3):1–19.
9. Thibaut L, Ceuppens S, De Loof H, et al. Integrated STEM education: A systematic review. *International Journal of STEM Education*. 2018;5(6):1–12.
10. Weisberg DS, Hirsh-Pasek K, Golinkoff RM. Guided play and learning outcomes. *Child Development Perspectives*. 2016;10(3):154–159.
11. Fleer M. Conceptual play: Foregrounding imagination and cognition in early childhood. *Contemporary Issues in Early Childhood*. 2011;12(3):224–240.

12. English LD. STEM education in early childhood: Challenges and opportunities. *International Journal of Science and Mathematics Education*. 2017;15(4):1–19.
13. Creswell JW. *Research design: Qualitative, quantitative, and mixed methods approaches*. 4th ed. Thousand Oaks: Sage Publications; 2014.
14. Miles MB, Huberman AM, Saldaña J. *Qualitative data analysis: A methods sourcebook*. 3rd ed. Thousand Oaks: Sage Publications; 2014.
15. OECD. *Early learning and child well-being: A study of five-year-olds in England, Estonia, and the United States*. Paris: OECD Publishing; 2020.