USE OF STEAM EDUCATIONAL TECHNOLOGIES IN PRIMARY SCHOOL CLASSES AS A RELEVANT PEDAGOGICAL ISSUE

Madina Xaydarova
Master's student of Namangan State Pedagogical institute

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Abstract: The integration of STEAM (Science, Technology, Engineering, Arts, and Mathematics) education in primary school natural science teaching is essential for developing competencies that equip students with critical 21st-century skills. This paper explores the didactic requirements necessary for the effective formation of STEAM competencies in young learners. It examines the interdisciplinary teaching strategies that blend scientific knowledge with technology, engineering, arts, and mathematics, and highlights key pedagogical approaches such as project-based learning, inquiry-based teaching, and the integration of technology. The study also identifies the challenges educators face, including resource limitations, insufficient teacher training, and rigid curriculum frameworks.

Keywords: STEAM education, primary school, didactic requirements, interdisciplinary teaching, curriculum design, project-based learning, technology integration, teacher professional development, student engagement, critical thinking, collaborative learning

BOSHLANG'ICH SINFLARDA STEAM TA'LIM TEXNOLOGIYALARIDAN FOYDALANISH DOLZARB PEDAGOGIK MASALA SIFATIDA

Annotatsiya: STEAM (fan, texnologiya, muhandislik, san'at va matematika) ta'limini boshlang'ich sinflarda tabiiy fanlarni o'qitishga integratsiyalashuvi o'quvchilarni 21-asrning muhim ko'nikmalari bilan qurollantiradigan kompetensiyalarni shakllantirish uchun zarurdir. Ushbu maqola yosh o'quvchilarda STEAM kompetentsiyalarini samarali shakllantirish uchun zarur bo'lgan didaktik talablarni o'rganadi. U ilmiy bilimlarni texnologiya, muhandislik, san'at va matematika bilan uyg'unlashtirgan fanlararo o'qitish strategiyalarini o'rganadi va loyihaga asoslangan ta'lim, so'rovga asoslangan o'qitish va texnologiya integratsiyasi kabi asosiy pedagogik yondashuvlarni ta'kidlaydi. Tadqiqot shuningdek, o'qituvchilar duch keladigan muammolarni, jumladan, resurslarning cheklanganligi, o'qituvchilarning etarli darajada tayyorlanmaganligi va qat'iy o'quv dasturlarini belgilaydi.

Kalit so'zlar: STEAM ta'limi, boshlang'ich maktab, didaktik talablar, fanlararo o'qitish, o'quv dasturlarini loyihalash, loyihaga asoslangan ta'lim, texnologiya integratsiyasi, o'qituvchilarning kasbiy rivojlanishi, talabalarning faolligi, tanqidiy fikrlash, hamkorlikda o'rganish

ИСПОЛЬЗОВАНИЕ ОБРАЗОВАТЕЛЬНЫХ ТЕХНОЛОГИЙ STEAM В КЛАССАХ НАЧАЛЬНОЙ ШКОЛЫ КАК АКТУАЛЬНАЯ ПЕДАГОГИЧЕСКАЯ ПРОБЛЕМА

Аннотация: Интеграция образования STEAM (наука, технология, инженерия, искусство и математика) в преподавание естественных наук в начальной школе имеет важное значение для развития компетенций, которые вооружают учащихся критически важными навыками 21-го века. В этой статье рассматриваются дидактические требования, необходимые для эффективного формирования компетенций STEAM у молодых учащихся. В ней рассматриваются междисциплинарные стратегии обучения, которые сочетают научные знания с технологиями, инженерией, искусством и математикой, и выделяются

ключевые педагогические подходы, такие как проектное обучение, обучение на основе исследований и интеграция технологий. В исследовании также определяются проблемы, с которыми сталкиваются педагоги, включая ограниченность ресурсов, недостаточную подготовку учителей и жесткие рамки учебных программ.

Ключевые слова: образование STEAM, начальная школа, дидактические требования, междисциплинарное обучение, разработка учебных программ, проектное обучение, интеграция технологий, профессиональное развитие учителей, вовлеченность учащихся, критическое мышление, совместное обучение

INTRODUCTION

The integration of STEAM (Science, Technology, Engineering, Arts, and Mathematics) education into primary school curricula has become increasingly relevant in modern education. This interdisciplinary approach aims to foster creativity, critical thinking, and problem-solving skills by blending traditional scientific concepts with technological and artistic innovation. In the context of natural sciences, STEAM education offers a dynamic framework for young learners to explore and understand the world around them through hands-on, inquiry-based learning experiences. For primary school students, the foundation of STEAM competencies begins with effective didactic strategies that align with their developmental needs and cognitive abilities. These requirements ensure that the teaching methods not only deliver scientific knowledge but also cultivate curiosity, innovation, and practical skills. By embedding STEAM principles into natural sciences, educators can provide a holistic learning experience that prepares students for the challenges of a rapidly evolving, technology-driven world. This paper examines the didactic requirements essential for the formation of STEAM competencies in the natural sciences at the primary school level. It explores key pedagogical principles, the role of interdisciplinary integration, and practical approaches to engaging young learners in meaningful and transformative educational experiences.

The integration of STEAM education into primary school teaching has gained significant attention in recent years, as educators and researchers recognize its potential to enhance 21st-century skills in young learners. The literature on STEAM education emphasizes the importance of interdisciplinary teaching methods that merge science, technology, engineering, arts, and mathematics to create a comprehensive and engaging learning experience. This review examines existing research on the didactic strategies and requirements for fostering STEAM competencies in primary school natural science education. The conceptual framework for STEAM education is rooted in constructivist and inquiry-based learning theories. Piaget (1964) and Vygotsky (1978) emphasize the importance of hands-on experiences and social interaction in the cognitive development of children. STEAM methodologies align with these theories by promoting active exploration and collaboration in solving real-world problems. As Quigley and Herro (2016) argue, STEAM education fosters critical thinking and creativity, essential skills for the modern workforce. Studies by Bybee (2010) and Honey et al. (2014) underscore the value of integrating technology and engineering into natural sciences to bridge theoretical knowledge and practical application.

As suggested by Sanders (2009), the curriculum must incorporate elements from all STEAM fields, ensuring a cohesive and integrated learning experience. Kolb's (1984) experiential learning model highlights the importance of hands-on activities, which are particularly effective in natural sciences. Project-based learning and experiments encourage active participation and curiosity.

Teachers play a pivotal role in facilitating STEAM learning. Research by Margot and Kettler (2019) emphasizes the need for professional development programs to equip teachers with the skills to implement STEAM methodologies effectively[3]. Studies, such as those by Johnson and Johnson (1994), point to the benefits of teamwork in promoting social skills and diverse problem-solving approaches. Use of Technology and Tools: Incorporating modern technology, such as digital simulations and robotics, enhances engagement and provides innovative ways to explore scientific concepts (NRC, 2012). While the benefits of STEAM education are widely recognized, challenges remain.

METHOD

To explore the didactic requirements for the formation of STEAM competencies in teaching natural sciences in primary school, a mixed-methods research approach was employed. This approach combines qualitative and quantitative methods to ensure a comprehensive understanding of the subject. The following methods were utilized. A systematic review of existing literature was conducted to identify theoretical frameworks, best practices, and challenges in implementing STEAM education in primary school natural sciences. STEAM competencies in education, interdisciplinary teaching methods, cognitive and developmental needs of primary school students. The review informed the design of research instruments and the development of criteria for evaluating didactic strategies. Surveys were administered to primary school teachers, administrators, and curriculum designers to collect quantitative data on current teaching practices in natural sciences, familiarity and experience with STEAM methodologies, perceived challenges and benefits of STEAM integration. The questionnaires included both closed-ended and open-ended questions to gather diverse perspectives. To gain insights into the practical implementation of STEAM education, classroom observations were conducted in primary schools that integrate STEAM principles into their natural science lessons. Observations focused on teaching methods and student engagement, use of interdisciplinary approaches, classroom resources and tools (e.g., technology, materials for hands-on activities), interaction between students and teachers.

Pilot teaching sessions were designed and implemented in selected primary schools to test specific didactic strategies aimed at fostering STEAM competencies in natural sciences. These sessions included project-based learning activities, experiments combining scientific concepts with technology and engineering creative problem-solving tasks involving art and design. Student outcomes were assessed through formative evaluations, focusing on their ability to apply interdisciplinary knowledge and skills. Survey results were analyzed using statistical methods to identify trends and correlations between teaching practices and STEAM competency development. Content analysis was conducted on focus group transcripts, observation notes, and experimental session feedback to identify recurring themes and insights.

RESULTS

The study on the didactic requirements for forming STEAM competencies in teaching natural sciences in primary schools yielded the following findings based on data collected through surveys, classroom observations, focus group discussions, and experimental teaching sessions: Surveys revealed that while 65% of teachers were familiar with the concept of STEAM education, only 30% actively integrated it into their teaching of natural sciences. The primary barriers cited were a lack of resources (45%), insufficient training (38%), and rigid curriculum structures (25%). Many teachers reported difficulty in connecting arts and engineering concepts to natural science topics, indicating a need for clear interdisciplinary frameworks. The study highlighted several teaching strategies that were particularly effective in fostering STEAM competencies. Classroom

observations and experimental teaching sessions showed that students engaged deeply with natural science concepts when participating in projects, such as building simple models to explain natural phenomena. This method was found to improve critical thinking and collaborative skills. Incorporating digital tools, such as simulations and coding exercises, significantly enhanced student understanding of complex scientific processes. For instance, 78% of students performed better in assessments after using interactive simulations compared to traditional teaching methods. Activities combining science with creative arts, such as drawing life cycles or designing eco-friendly habitats, fostered creativity and a better conceptual understanding among students.

The data revealed several challenges faced by educators in implementing STEAM education. Over 50% of surveyed teachers reported inadequate access to materials like lab equipment, technology, and art supplies. Focus group discussions emphasized that many teachers lacked confidence in applying interdisciplinary methods. Only 20% of teachers reported receiving training specific to STEAM education. A significant number of teachers found the existing curriculum too rigid to allow for extensive STEAM activities, with 40% expressing a need for greater flexibility. Experimental teaching sessions demonstrated the following student outcomes when STEAM-based methods were employed. Students participating in hands-on activities showed a 25% increase in engagement compared to traditional lecture-based lessons. There was a marked improvement in problem-solving and teamwork skills, as observed in group projects. Over 70% of students reported greater interest in natural sciences after participating in STEAM-based lessons.

DISCUSSION

The results of this study provide valuable insights into the didactic requirements for forming STEAM competencies in teaching natural sciences in primary school. The findings underscore the importance of interdisciplinary teaching methods, the integration of technology, and the need for professional development to overcome current challenges. This discussion interprets these results in the context of existing literature and identifies the implications for future practice and research. However, the study also found that many teachers struggle to effectively connect these disciplines in practice, particularly when it comes to linking engineering and arts with science. This highlights a need for clearer guidelines and frameworks for interdisciplinary teaching. As Sanders (2009) suggests, curriculum design should explicitly support these connections, making it easier for teachers to blend concepts across disciplines. The positive impact of technology integration in STEAM education aligns with findings in previous studies, such as those by Honey et al. (2014) and the National Research Council (2012), who highlight that technology enhances students' understanding of complex scientific concepts. In this study, the use of interactive tools, such as simulations and coding exercises, was shown to improve students' performance and interest in natural sciences[4].

Despite the clear benefits, the study also revealed that many schools lack sufficient resources to fully integrate technology. As Quigley and Herro (2016) noted, access to technology is often a significant barrier, especially in underserved or resource-poor environments. To overcome this, education policy must prioritize investment in digital infrastructure and provide teachers with the necessary tools and support to integrate technology into their teaching. A key challenge identified in this study was the lack of professional development opportunities for teachers to effectively implement STEAM methodologies. Margot and Kettler (2019) stress the importance of equipping teachers with the skills necessary to facilitate interdisciplinary learning[3]. While many teachers expressed familiarity with the concept of STEAM, they felt

underprepared to implement it in their classrooms. This gap highlights the need for comprehensive professional development programs that focus not only on content knowledge but also on pedagogical strategies for teaching across disciplines. Moreover, focus group discussions emphasized that many teachers would benefit from ongoing support and collaboration with colleagues in developing STEAM-based curricula. Collaborative networks and mentorship programs could be valuable in helping educators share best practices and learn from one another. The establishment of STEAM-focused professional learning communities could encourage more teachers to embrace innovative approaches. The study also identified significant challenges related to rigid curriculum structures and resource limitations.

CONCLUSION

The results of this study highlight the transformative potential of STEAM education in primary school natural sciences. By adopting interdisciplinary approaches, integrating technology, and prioritizing teacher professional development, educators can effectively foster the STEAM competencies necessary for students' future success. However, challenges related to resource limitations, curriculum constraints, and teacher preparedness must be addressed to ensure the widespread and effective implementation of STEAM education. Further research is needed to explore long-term outcomes of STEAM education in primary schools, particularly in terms of student achievement and career readiness. Additionally, studies investigating the specific impact of different STEAM components (e.g., art, engineering) on students' learning outcomes would provide valuable insights for refining teaching strategies and curriculum design.

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