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Methods Of Implementing Steam Educational Technologies In Primary Education

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Annotation. This article discusses the modern significance, opportunities, and achievements of STEAM technologies as well as their advantages in the educational system. The article is useful for students, independent researchers, and educators.

Keywords: STEAM technologies, quality of education, ability, foreign pedagogy, integration, science, technology, engineering, art, mathematics, developmental center, integration.

Introduction

Modern trends in global education—particularly interdisciplinary approaches, digital literacy, problem-solving skills, creativity, and teamwork—are increasingly being integrated into educational curricula as the essential competencies of the 21st century. In this regard, countries such as the United States, Finland, Singapore, Japan, and South Korea widely apply educational systems based on the STEM (Science, Technology, Engineering, Mathematics) concept. In recent years, these systems have successfully expanded into the STEAM model, which incorporates art and creativity.

In Finnish schools, for example, students participate in real-life, interdisciplinary projects that enable them not only to acquire theoretical knowledge but also to develop social activity, independent thinking, and research-based problem-solving skills within an environment designed for such purposes. International analytical reports from UNESCO and the OECD also identify the integration of education, the strengthening of practical activities, and the expansion of creative approaches as important innovative directions.

STEAM education contributes not only in higher grades but also from the primary level by developing students' intellectual potential, creative research abilities, and the skill to understand logical connections between disciplines. Because this approach encourages learning through new conceptual frameworks, solution-oriented thinking, and innovation, it has become a significant priority in global education policy.

Extensive research is being conducted worldwide to improve the theoretical and practical foundations of STEAM-based teaching, enhance educational quality, develop 21st-century skills, and strengthen creativity and interdisciplinary analytical competence among learners. Initiatives such as Project Lead The Way in the United States, the STEM School Label in the European Union, and the Integrated Inquiry-Based Learning project in Canada aim to transform school education by fostering integration, research, design, and interdisciplinary approaches.

International organizations such as the OECD and UNESCO emphasize connecting subjects with practice, shaping students as active participants, and ensuring the relevance of educational content as key priorities. Improving the methodological foundations of STEAM technologies is considered necessary to enhance competitiveness, social relevance, and innovation capacity in education. Since the need to develop interdisciplinary thinking, creativity, and analytical abilities from the early stages of schooling is growing, this issue is becoming increasingly important.

In Uzbekistan, recent educational reforms—including the Law "On Education," the "Concept for the Development of Education Until 2027," and the "New Uzbekistan School" initiative—place special emphasis on improving the quality of education and bringing it to international standards. In primary education, integrating subjects, encouraging independent thinking, fostering creativity, and developing students' research motivation are essential requirements. However, in practice, methodological approaches in this area are not yet sufficiently developed, and many lessons are still conducted in traditional, reproductive formats, revealing the need for modernization in educational content.

President Shavkat Mirziyoyev, defining the main goals of education and upbringing, stated: "To provide preschool and school education systems with scientific and methodological support, conduct fundamental, applied, and innovative research, and widely implement research results into practice."

Given these circumstances, scientifically introducing STEAM educational technologies into primary education, developing its methodology, and implementing active, interdisciplinary teaching methods have become urgent tasks in the educational sector.

The Presidential Decree PF-5712 of April 29, 2019 "On the Approval of the Concept for the Development of the Public Education System Until 2030," Resolution PQ-4119 of January 16, 2019 "On Additional Measures to Improve the Education Quality Control System," Resolution PQ-4623 of February 27, 2020 "On Measures to Further Develop Pedagogical Education," as well as the Cabinet of Ministers' Resolution No.1059 of December 31, 2019 "On the Approval of the Concept of Continuous Spiritual Education," and Resolution No.331 of May 27, 2021 "On Additional Measures for Improving Extracurricular Education," and other related regulatory documents play an important role in ensuring the implementation of these tasks. This dissertation research serves to contribute to the execution of the objectives set forth in the above-mentioned documents.

The STEAM educational concept has emerged as an integrative approach that combines science, technology, engineering, art, and mathematics into a unified system of knowledge. This approach reflects the multidisciplinary nature of modern education and aims to develop students' critical thinking, creative problem-solving, and the ability to apply practical knowledge in real-life situations. The development of this educational model is recognized as a response to technological advancements, as well as to the growing need to integrate practice and aesthetic awareness in learning.

STEAM education aims to prepare students not only for the exact sciences but also for addressing complex social and ethical issues. For this purpose, it is vital that knowledge is acquired not only on a rational basis but also through emotional and aesthetic dimensions. Such an approach, in turn, creates opportunities for the learner's holistic development. "The STEAM acronym is formed by adding the component of Art to the traditional STEM model. The inclusion of art acknowledges the significance of creativity, imagination, and artistic expression within the learning process." Through STEAM, students can harmoniously develop not only rational but also emotional and creative abilities, which is crucial for ensuring the sustainability and relevance of education.

In recent decades, the interdisciplinary approach has become one of the fundamental pillars of education. Solving complex real-life problems increasingly requires the integration of knowledge from different disciplines. In this respect, the American researcher J. Bruner is considered one of the first scholars to scientifically justify the need for interdisciplinary integration by criticizing the practice of teaching subjects in isolation. He emphasized that integrating various fields of knowledge within the learning process develops students' long-term problem-solving thinking, stating:

"Interdisciplinary education forms lifelong problem-solving skills by unifying knowledge from different domains and equips learners with the ability to transfer information from one context to another."

From this perspective, Bruner's ideas provide an important theoretical foundation for the formation of the STEAM model. His views serve as a firm basis for educational models aimed at understanding the

interconnectedness of disciplines, applying knowledge in new contexts, and fostering independent thinking.

G. Yakman is recognized as one of the first researchers to scientifically structure the STEAM educational concept. Her most significant contribution lies in adding the element of Art to the STEM model, thereby transforming education into an environment that supports not only logical development but also creativity and emotional growth. Yakman regards the cultivation of aesthetic thinking, creative reasoning, design, and artistic perception as essential components of educating a modern citizen: "STEAM is not simply adding art to STEM; rather, it deepens understanding and fosters innovation by consciously integrating creative processes with analytical thinking."

Theoretical Foundations of STEAM Education. STEAM educational technology is linked to several fundamental principles of contemporary educational reforms:

Constructivist Theory. Constructivism views the learner not as a passive recipient of information but as an active constructor of knowledge through personal experience, observation, reflection, and engagement.

Social Learning Theory. The psychologist and pedagogue Lev Semyonovich Vygotsky scientifically substantiated the socio-historical and cultural foundations of education. According to his theory, learners do not acquire knowledge independently; rather, they internalize it through communication, collaboration, interaction, and support within a social environment. He defines the nature of learning as "a process of transition from interpersonal interaction to individual understanding."

Experiential Learning Theory. American pedagogue, philosopher, and social reformer John Dewey became known for his revolutionary ideas in early 20th-century education. His pedagogical concept, based on pragmatism and interactive learning, emphasizes not memorization or repetition but learning by doing—the formation of knowledge through hands-on activity and real-life experience.

STEAM in Primary Education. In primary education, organizing learning not as isolated subjects but through interconnected content has become an essential methodological requirement. In traditional, segmented teaching, each subject is presented as an independent block, which fragments the learner's overall cognitive image and decreases the ability to connect knowledge with real life and apply it in authentic contexts.

Since primary-school children naturally tend to acquire knowledge in a holistic, logical, and interconnected manner, integrated teaching encourages interdisciplinary comprehension, generalized thinking, and the ability to generate complex solutions.

On this issue, the American researcher Heidi Hayes Jacobs states:

"Integrating subjects not only deepens knowledge but also develops the ability to perceive interdisciplinary connections, apply knowledge in new contexts, think reflectively, and engage actively in learning."

Jacobs' view supports the idea that integrated instruction enriches educational content, strengthens long-term memory retention, and creates favorable conditions for applying knowledge in practice.

Material and Technical Capacity in Uzbekistan. In recent years, the material and technical base of general secondary schools in Uzbekistan has been gradually improved to ensure interdisciplinary integration among natural sciences, mathematics, reading literacy, and character education. The establishment of Presidential Schools, Creative ("Ijod") Schools, and IT Schools, as well as the introduction of modern laboratories, STEM equipment, interactive tools, microscopes, drafting instruments, projectors, and electronic boards, all demonstrate the enhanced potential of the current infrastructure.

This modernized material base plays a key role in organizing new-format lessons—topic-based interdisciplinary activities, project-based learning, and the implementation of STEAM practices. In such lessons, instead of teaching each subject separately in a traditional manner, connections among disciplines are demonstrated within a single thematic framework. As a result, students analyze the topic from multiple perspectives and actively integrate the knowledge into their cognitive system.

The methodology for implementing the STEAM model in primary grades is based on centering learning activities, activating students' thinking, and understanding the connections between different subjects. This, in turn, helps develop strong competencies in students through the chain of "knowledge – skill – application." In this process, the teacher's role is to identify interdisciplinary

connections, integrate lesson content, engage students as active participants, and create an interactive environment through questions that stimulate thinking.

One of the most effective solutions in organizing lessons is project-based learning. Project activities encourage the learner to act not only as a recipient of knowledge but also as an active creator, researcher, designer, tester, builder, and presenter. For example, projects such as "Creating a model of a water purifier using recyclable materials," "Constructing geometric shapes using numbers and basic figures," or "Creating a panel that illustrates natural phenomena based on a story," allow students to integrate several subjects within a single learning activity. The visual and activity-based methods used in STEAM lessons include diagrams, models, projects, competitions, experiments, infographics, mind maps, and creative writing tasks. Through these methods, learners do not only listen or read but also observe, feel, create, and present information. Group work and role-based tasks also play a significant role. Each student takes on roles such as "engineer," "specialist," "designer," "leader," or "accountant," which enhances collaboration, responsibility, critical thinking, and problem-solving skills. Furthermore, STEAM-based lessons use alternative assessment methods such as reflection sheets, self-assessment scales, group presentations, and peer review rather than teacher-dominated evaluations.

In primary school, the reading literacy subject not only focuses on answering questions or understanding texts, but also aims to develop students' analytical thinking, ability to draw conclusions beyond the text, participation in discussions, and expression of personal views. Especially in STEAM education, integrating reading literacy with other subjects serves as an important tool for developing interdisciplinary thinking, social awareness, and cultural perception. Reading materials include not only literary texts but also thematic texts that introduce ecological, technological, scientific, and philosophical issues to children in a pleasant, engaging, and age-appropriate manner. For example, texts on topics such as "Energy sources," "Environmental protection," "Labor and professions," and "Information technologies" help students develop a scientific worldview as well as emotional and moral attitudes. One of the most essential aspects of this process is the development of dialogic thinking. The learner not only reads the text but also asks questions, critically analyzes it, expresses personal opinions, listens to others' viewpoints, and provides commentary. Questions such as "What does it mean to love one's homeland?" "What is the role of a working person in society?" or "Why should we save water?" enable children to connect their life experiences with the knowledge gained from different subjects.

Thus, the learner perceives reading activity not merely as interacting with a text but as engaging with a problem and its meaning. Presenting texts in visual, multimodal, diagram-based, or comparative forms enhances students' verbal activity, analytical thinking, and social awareness.

STEAM-based reading lessons aim to develop scientific thinking, ecological consciousness, moral attitudes, creative reasoning, and social identity in learners. In such lessons, the learner becomes not a passive receiver of information but an active social subject, participant in communication, initiator, and creative individual.

Modern education requires students to be not only recipients of knowledge but also active researchers, problem-solvers, and creators. In primary school especially, it has become necessary to connect subjects with real-life situations and teach through solving practical, reality-based tasks. Project-Based Learning (PBL), widely used in STEAM education, serves precisely this purpose. In this model, the content, skills, and practices of multiple subjects are integrated within a single theme.

The topic "Why should we protect nature?" in the 2nd grade Natural Science textbook (O.I. Tigay. Natural Sciences. Grade 2. Part I. Textbook for general secondary schools. Tashkent: Novda, 2023, p. 88) serves as an ideal foundation for PBL. Within this topic, a mini-project titled "Let's Preserve Nature!" can be implemented. This project not only fosters love for nature but also teaches students ecological thinking through interdisciplinary learning.

During the project:

- Through Natural Science, students learn about plants and animals, and the impact of human activities on the natural environment.
- In Reading Literacy, they prepare articles, announcements, stories, or calls to action on the topic "Let's Preserve Nature!"

- In Technology, they create recycling bins, ecological models, or visual advocacy posters from recyclable materials.
- In Mathematics, they calculate ways to reduce the use of paper, water, and electricity.

Conclusion. Based on the research conducted on the topic "Methodology of Implementing STEAM Educational Technologies in Primary School," the following conclusions were drawn:

1. The integrative model shaped on the basis of the STEAM concept enhances functional comprehension in primary education by combining cognitive, practical, and creative activities. This model creates the conditions for reconstructing knowledge through real-life application and personal understanding. Interdisciplinary connections in the learning process broaden opportunities for developing creative thinking. This approach serves to ensure strategic effectiveness in education.
2. Methodological approaches shaped within modern educational paradigms provide a solid foundation for introducing interdisciplinary integration into primary education content. Here, learner agency, cognitive flexibility, and research-based activities play a central role. Approaches such as syncretic understanding and visual-verbal activation reinforce learning activity. Such a system develops cognitive and creative abilities in parallel.
3. The possibilities for integrating subjects within the STEAM framework in primary education become evident through goal-oriented learning processes, functionally structured content, and methodologically coherent approaches that support interdisciplinary connections and practical-creative activities. Each subject contributes to the integration with its distinct content function. Interrelated activities strengthen the logical and practical foundation of education, while students' comprehension, reasoning, and creativity develop systematically.
4. The STEAM model developed within the scope of this research made it possible to reorganize educational content, methodology, and outcome indicators based on the principle of learner agency. The model includes components that integrate comprehension, reasoning, and creative activity. Visualization, quests, case studies, and design thinking were introduced as key methodological tools. Such an approach serves as an important factor in activating the learning process.
5. Methodical solutions aimed at developing critical and independent thinking were adapted to the educational content through the integration of cognitive flexibility, creative design, and neuro-pedagogical mechanisms. Elements of emotional impact, subjective understanding, and reflective analysis were incorporated into the methodical model. Students developed skills such as generating personal opinions, making choices, decision-making, and participating in social interactions. These solutions reinforce learner agency in the educational process.

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