ISSN: 3067-929X
Review Article

Journal of Electronics Science and Electrical Research

Implementation of Stem Education in The Higher Education System

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Submitted: 28 July 2025 **Accepted:** 07 August 2025 **Published:** 13 August 2025

https://doi.org/10.63620/MKJESER.2025.

Citation: *Aripova, G., Boboyev, A., Tojiboyeva, M. (2025). Implementation of Stem Education in The Higher Education System. J of Electron Sci and Electrical Res 2(3), 01-04.*

Abstract

This article discusses the issues related to the implementation of STEM education in Uzbekistan, which significantly contributes to the country's scientific and technological development. This system prepares students to enhance global competitiveness, adapt to modern professions, and develop innovative thinking. By introducing STEM education in higher education institutions, students become professionals equipped with interdisciplinary knowledge and practical skills. The core principles of STEM education differ from traditional educational models, as the learning process is not limited to theoretical knowledge but focuses on developing students' practical and creative activities. Thus, in line with the demands of the 21st century, STEM education provides a strong impetus for Uzbekistan's scientific, technological, and economic progress.

Keywords: STEM, Innovation, Integration, Globalization, Education.

Introduction

In today's era of globalization and digital technologies, the STEM approach (Science, Technology, Engineering, and Mathematics) has become one of the main priority directions in education systems worldwide [1]. In Uzbekistan's higher education system, the practical implementation of this approach considers revising one of the most pressing issues. The main reasons for this can be seen in the following:

Training Competitive Professionals: The global market increasingly demands specialists who are capable of producing high-tech products, think analytically, and solve complex problems.

The Foundation of an Innovative Economy: Developed countries achieve sustainable economic growth primarily by training highly qualified personnel in STEM fields.

Rapid Advancement of Science and Technology: Areas such as artificial intelligence, digital transformation, biotechnology, engineering, and energy are directly linked to the development of STEM education.

Advantages of an Integrated Approach to Education: STEM strengthens interdisciplinary connections. For example, chemistry is taught in combination with elements of mathematics, computer science, or engineering, making the learning process more relevant to real-world situations.

Fostering Creativity and Critical Thinking: STEM education not only provides technical knowledge but also develops essential 21st-century skills such as problem-solving, generating innovative ideas, and independent critical thinking.

Unlike traditional education, STEM education is based on an interdisciplinary and practical approach. It shifts the focus of curriculum analysis from merely redesigning curricula to their actual implementation, emphasizing:

• modifying the curriculum as part of a broader system of change management;

• aligning curriculum changes with pedagogical assessment;
• adapting educators involved in primary education and professional development to changes in the curriculum.

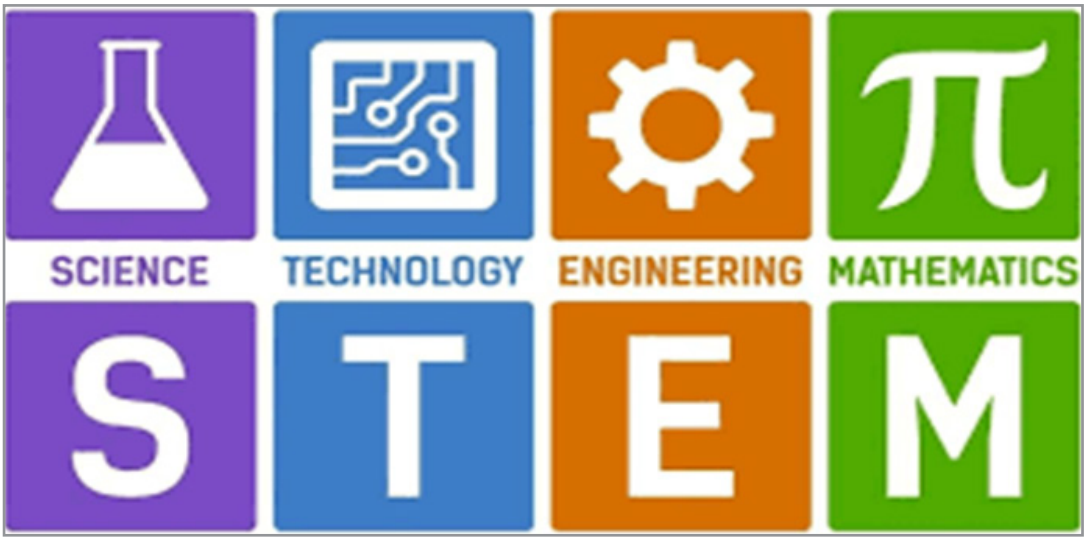
This is examined through sector-specific research analyses, surveys on curriculum implementation, stakeholder consensus, and considerations of global inequalities [2]. Therefore, practical steps have been taken to implement the STEM model into the educational process in Uzbekistan. According to available sources, the number of children aged 3 to 7 in the Republic of Uzbekistan is 2,930,844. Of these, 74 percent - or 2,169,538 children - attend preschool institutions. Currently, 500 children in preschools are receiving education based on the STEM approach, which accounts for only 0.02 percent of all children in the country [3, 7]. According to 2024 statistical data, more than 6.5 million students are enrolled in general secondary education institutions in Uzbekistan. Additionally, preschool education institutions cover over 1.5 million children, and more than 300,000 students are studying at higher education institutions. These figures indicate that the education system in the country is expanding and that public interest in education is steadily increasing [3, 7].

There is available data on the number of specialized schools in Uzbekistan focused on in-depth subject teaching and their areas of specialization. As of 2020, there were 420 specialized schools and boarding schools in the Republic of Uzbekistan dedicated to advanced instruction [5], including:
• 243 schools specialized in exact sciences;
• 41 schools specialized in natural sciences;
• 23 schools specialized in social sciences;
• 32 schools specialized in philological sciences;
• 81 schools specialized in foreign languages.
A total of 58,470 students are studying in these specialized schools.

It is planned that, starting from the 2025/2026 academic year, the educational process in specialized schools will be organized based on the STEM model. However, at present, not all of these specialized schools have implemented an educational process based on the STEM model. In the specialized schools where the STEM model has been introduced, more than 1,632 students are receiving education. This number accounts for only 0.03 percent of students studying in specialized schools across the Republic of Uzbekistan [8].

In certain higher education institutions in Uzbekistan, special attention is being given to developing students' knowledge and skills in STEM fields. Educational and methodological materials are being developed to support the implementation of STEM education. Such initiatives represent important steps toward advancing STEM education in higher education institutions [3,6]. The content of the STEM education model is currently an essential component of many ongoing projects. However, its effective implementation largely depends on creating a new scientific and spatial environment across the entire education system, as well as updating its content, software, and methodological support.

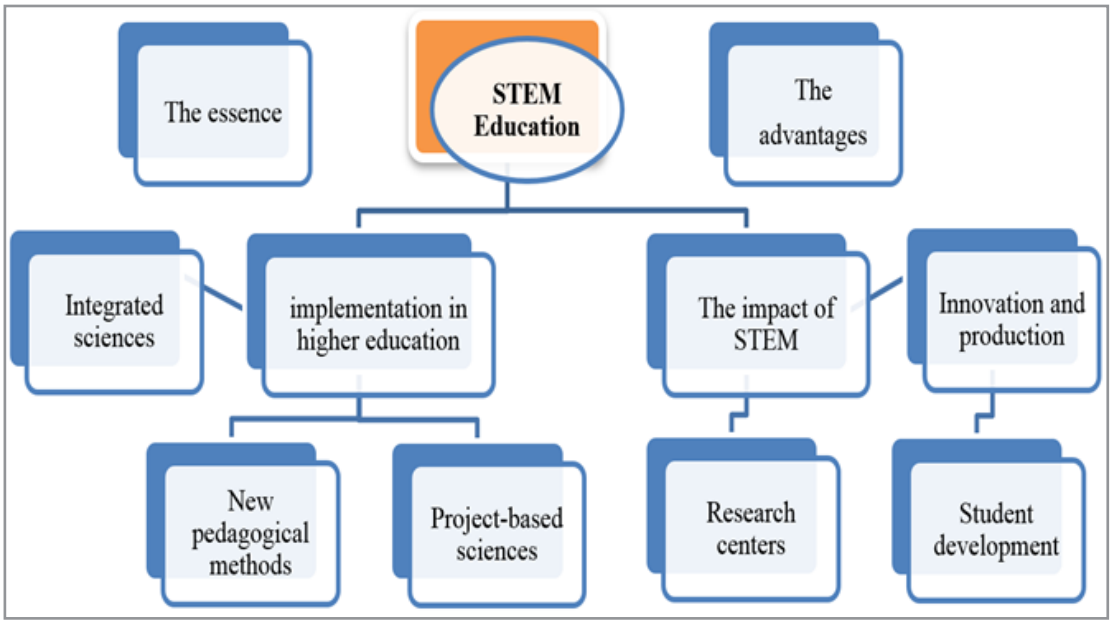
In many institutions, the lack of STEM laboratories hinders the ability to provide children with adequate knowledge. The primary goal of STEM education technology is to develop children's intellectual abilities by engaging them in scientific and technical creativity through the use of modern information and communication technologies. STEM technology is being actively used in countries such as the United States, Russia, and Germany. The ages of 3 to 7 represent a critical stage in child development. Educators working with preschool-aged children understand the importance of sparking curiosity for learning, teaching them to perceive and use information from various sources, and helping them independently find answers to questions about the world around them.



It is important to develop preschool-aged children's ability to act independently and collaborate with peers and adults. This raises a key question for educators: What methods and technologies should be used to support the development of young children? STEM education technology was originally developed in the United States. American researchers, based on various experiments, considered the abilities of some high school graduates and decided to integrate subjects such as Science, Technology, Engineering, and Mathematics—leading to the formation of the STEM system (Science, Technology, Engineering, Mathematics). Later, the "A" for Art was added to emphasize creativity and design thinking, expanding the model into STEAM.

According to researchers, knowledge in these subjects—partic-

ularly in the STEM fields—helps students become highly qualified specialists in the future. In a STEM laboratory, children are motivated to acquire strong knowledge and have the opportunity to apply it immediately in practice. STEM education integrates science, technology, engineering, art, and mathematics to promote hands-on, experience-based learning. It is aimed at fostering creative thinking, innovative approaches, and the development of practical knowledge and skills.



In the higher education system of the Republic of Uzbekistan, the role of STEM is based on its comprehensive and creative approach. This approach prepares students to solve modern challenges and address issues related to new technologies and scientific research. The STEM system helps elevate higher education to a new level that meets the demands of today. The implementation of STEM education in Uzbekistan's higher education system is making a significant contribution to the country's scientific and technological advancement. This model plays a crucial role in developing innovative thinking among young people, enabling them to adapt to modern professions, and serving as a key factor in the growth of the national economy [4].

Therefore, Applying STEM Principles in Higher Education Should be Considered a Top Priority.

1. Core Principles and Content of STEM:

STEM education focuses on developing creative thinking, innovative approaches, and knowledge through practical experience by integrating science, technology, engineering, art, and mathematics. It helps foster critical thinking, problem-solving, and interdisciplinary, complex reasoning skills in higher education.

2. STEM Development in Uzbekistan:

In Uzbekistan's higher education system, STEM-related developments and courses aim to prepare highly qualified professionals in a modern scientific and practical environment. Higher education institutions in Uzbekistan are paying special attention to STEM education, as it helps students acquire the skills necessary for implementing future innovative projects.

3. Integration of STEM in Education:

The implementation of STEM in higher education is reflected in several areas:

- Integrated Subjects: The fusion of physics, mathematics, and technology with art and engineering. For example, the role of art and the importance of design in engineering projects.
- Project-Based Learning: Students learn by solving real-life problems in practice, which enhances their creative and technical abilities.
- New Pedagogical Methods: STEM education requires not only theoretical knowledge but also practical and creative approaches to problem-solving. For instance, higher education institutions conduct project work, laboratory sessions, internships, and scientific-practical research.

4. STEM Curricula and Projects:

Specially developed STEM-based curricula and projects in Uzbekistan provide students with knowledge that meets the demands of the modern era. For example, STEM-based projects are being implemented in fields such as energy and energy efficiency, solar energy, veterinary science, biotechnology, and more. Projects involving 3D printing or robotics illustrate the integration of art and engineering, where students design devices and systems based on functional requirements and creative solutions.

5. STEM-Related Activities in Higher Education Institutions:

- Research Centers: Scientific research centers have been established within STEM education to cover each specific direction of the exact sciences. Research is being conducted in fields such as science and technology, renewable energy sources, and information technologies.
- Implementation and Project Development:
- The STEM education system supports the introduction of new technologies in higher education institutions by guiding students toward conducting scientific research and implementing innovative projects.

6. Impact on Students' Professional Development:

- In STEM education, universities play a vital role in developing students as young innovators, researchers, and professionals. This system enables students to achieve success across technical, scientific, and creative fields simultaneously.

By its very nature, STEM represents a dynamic system of innovation and process renewal. As a form of systemic transformation, innovation reflects the internal essence of relationships or processes, the rapid development of newly introduced ideas within a specific timeframe, and their mutual impact on the surrounding environment [9].

Conclusion

In conclusion, the integration of STEM education into the higher education system of the Republic of Uzbekistan is based on interdisciplinary and creative approaches that align with the demands of the modern world. STEM is playing an increasingly vital role in shaping a new educational paradigm, as it equips students not only with theoretical knowledge but also with practical skills, problem-solving abilities, and innovative thinking.

By encompassing science, technology, engineering, and mathematics - along with elements of art and creativity - STEM education provides a comprehensive learning environment. This approach enables students to effectively solve complex real-world problems, adapt to rapidly evolving technological landscapes, and actively participate in research-based and investigative activities.

Furthermore, the implementation of STEM in higher education institutions contributes to building a future-oriented workforce. It supports innovation, fosters national economic growth, and helps form a new generation of highly qualified specialists capable of active participation in the global knowledge economy. The continued development and expansion of STEM programs, research centers, and project-based learning across universities in Uzbekistan reflect a strong commitment to educational modernization. This strategic direction not only enhances academic quality but also ensures that graduates are prepared to confidently and competently address the challenges of the 21st century. Thus, prioritizing STEM education within Uzbekistan's higher education system is not only a timely decision, but also a long-term investment in the nation's scientific, technological, and socio-economic progress.

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