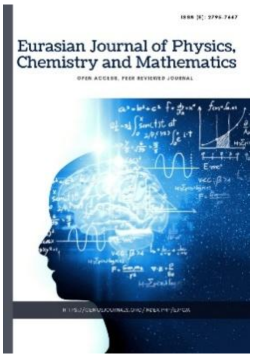

Stem Education In Primary School

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ABSTRACT

The article explores the role of innovative educational technologies, particularly the STEM education concept (Science, Technology, Engineering, Mathematics), in preparing specialists capable of meeting the challenges of modern society. It addresses the need to enhance human competitiveness amidst rapid technological progress and competition with artificial intelligence. Special attention is given to the integration of STEM approaches into the educational process, including interdisciplinary and practice-oriented methods that foster the development of critical thinking, creativity, and engineering competencies. Examples of STEM education implementation in Uzbekistan, aligned with national programs, are provided, alongside an analysis of global experiences and trends in this field. The article emphasizes the importance of STEM in shaping a new generation of professionals ready for innovative activities in the context of globalization.

Keywords: STEM education, innovative learning technologies, competitiveness, interdisciplinary approach, engineering competencies, critical thinking, creativity, educational policy, globalization, professional training.

Introduction

The modern era is marked by the rapid advancement of science and technology, placing new demands on individuals as professionals. To remain competitive not only with other specialists but also with artificial intelligence, it is essential to train a workforce capable of innovative solutions, flexible adaptation to change, and continuous development of their skills throughout their lives. In this context, innovative learning technologies, particularly the STEM education concept integrating science, technology, engineering, and mathematics, play a pivotal role. The STEM approach focuses on addressing real-world problems through practice-oriented and interdisciplinary methods, promoting the development of key competencies such as critical thinking, teamwork, and self-organization. This article examines both the theoretical foundations of STEM education and its practical implementation, including examples from Uzbekistan's educational policy and global trends.

Meeting the requirements of the new era requires a person to be competitive not only with other experienced specialists, but also with artificial intelligence. This requires creative training of the workforce, namely those who will be ready for innovative solutions to real problems, the development of their own abilities throughout their lives, those who are able to quickly and flexibly adapt to new requirements, criteria, assessments, values of society and, if necessary, to radically change the scope of professional activity given the high speed of change in industries in the conditions of rapid development of science and technology (e.g., Konyushenko et al., 2018; Shalashova et al., 2017; Basham & Marino, 2013; Sanders, 2009).

The concept of "learning technology" is defined as a set of methods and means for delivering certain course content in the context of one subject or specific types of educational activity (Shalashova et al., 2017). Taking into account the above, by "innovative learning technologies" we will understand the purposeful, systematic and consistent implementation in pedagogical practice of original, innovative pedagogical methods, techniques and means that cover the entire educational process from defining its goal to the expected results. The main way of introducing pedagogical innovation into educational reality is the integration and implementation of various original approaches based on philosophical, psychological, pedagogical research, new achievements of information technology, which determine the instructional strategy and are implemented in the system of scientific and methodological activity.

STEM means engineering design. Engineering design is all about solving problems and developing solutions that take into account constraints, as engineers call them. It is a type of in-depth inquiry that allows school students to see the relationship between STEM design, research, and implementation of a solution. This approach can also support transition planning by giving school students the opportunity to explore multiple STEM-related careers and even opportunities to track their own work (examples of such careers include engineers, surveyors, construction workers, etc.) (Basham & Marino, 2013).

Integrative STEM education includes approaches that explore learning across any two or more STEM subject areas and/or across school subjects. Also, STEM education cannot be separated from social and aesthetic contexts. The study of technology should not be isolated from the study of social sciences, arts, and humanities (Sanders, 2009).

In pursuance of the Decrees of the President of the Republic of Uzbekistan No. 134 "On Approval of the National Program for the Development of School Education in 2022-2026", issued on May 11, 2022 and No. 79 "On Measures for the Effective Organization of the Activities of the Ministry of Preschool and School Education and Organizations in its System", issued on May 26, 2023 (Decree of the President of the Republic of Uzbekistan No. 134; Decree of the President of the Republic of Uzbekistan No. 79), several tasks are given, such as the introduction of foreign textbooks based on international requirements in general secondary educational institutions. In order to ensure the continuity of preschool and primary school education, a special electronic platform named "Card of readiness of a child aged 6-7 years for school", and others are being introduced. It should also be noted that according to the statistics from the Ministry of Preschool and School Education, more than 50% of schoolchildren attend additional education institutions, while only 4% of them are involved in scientific and technical creativity. At least 75% of children aged 5 to 18 years should be involved in extracurricular activities, and the scope of scientific and technical creativity should increase by 2-2.5 times.

The implementation of STEM education actively helps to implement the tasks set by the President and the Government. The abbreviation STEM stands for Science, Technology, Engineering and Mathematics. It should be noted that these disciplines are coming to the fore not only in education, but also in economics and power engineering.

Practice-oriented and interdisciplinary approaches, in which school students use knowledge from different fields to solve a specific practical problem, form the basis of STEM education. This is called engineering and technical competencies, which, in addition to the technical base, include critical thinking, the ability to work in a team, present and defend your project. In education, the STEM approach is used in the study of mathematics, physics and robotics (Yankovskaya, 2018). Today, STEM education connects the educational process, career and further professional growth into a single whole.

In the article (Kairzhanova, 2023), the author examines the impact of modern society faced with rapid information and technological progress on the development of human qualities such as critical thinking, creativity and self-organization. She emphasizes the special role of STEM education, which combines science, technology, engineering and mathematics, in training specialists capable of coping with modern challenges and bringing innovative and sustainable solutions to society.

With the global recognition of the growing importance of STEM education, we have seen a pressing need to support research in the field of STEM education (Li, 2014; Li, 2018). Researchers and educators have responded to this ongoing call and have published their research in many different outlets including journals, books, and conference proceedings. A simple Google search for the term "STEM" or "STEM education" yielded over 500,000,000 entries. This wealth of information shows the rapidly evolving and dynamic field of STEM education and sheds light on the scope of STEM education research. In any field, it is important to know and understand the status and trends in the field so that it can grow and receive appropriate support. This is also true for STEM education.

Conducting systematic reviews to examine the status and trends in specific disciplines is common in educational research. For example, researchers have examined the historical development of mathematics education research (Kilpatrick, 1992) and patterns of technology use in mathematics education (Bray & Tangney, 2017; Sokolowski et al., 2015). In natural science education, Tsai and colleagues conducted a series of reviews of journal articles to synthesize research trends for every 5 years since 1998 based on the publications in three major natural science education journals (e.g., Tsai & Wen, 2005; Lin et al., 2019). Authors (Erduran, Ozdem & Park, 2015) reviewed argumentation in natural science education research, and authors (Minner, Levy & Century, 2010) reviewed inquiry-based natural science instruction. There are also many literature reviews and syntheses in engineering and technology education (e.g., Borrego, 2015; Xu et al., 2020). All of these reviews have been well received in various areas of traditional disciplinary education because they critically evaluate and summarize the current state of relevant research in the field as a whole or with a specific focus. Both types of reviews were conducted using different methods to identify, collect and analyse relevant publications, and they differ in terms of the objective of the review and the scope of the topic, the time period and the methods of literature selection.

The concepts of STEM and STEAM education are recognized among the most promising modern approaches to training new generation specialists, focused on innovative activities in the modern conditions of social mobility, world-scale globalization, economic, political and cultural integration in most developed countries of the world. These concepts are considered pedagogical innovations of the 21-st century.

STEM is implemented through all types of education, namely: formal, non-formal, informal (using online platforms, in STEM laboratories), by conducting excursions, competitions, contests, festivals. In addition, it is mandatory to involve specialists in the development of software and computer programs for each STEM subject.

According to the results of analytical studies, out of 10 specialties that have a high level of demand, 9 require STEM knowledge. In particular, the demand for such specialties as chemical engineers, software developers, petroleum engineers, computer systems analysts, mechanical engineers, civil engineers, robotics engineers, nuclear medicine engineers, underwater architects, aerospace engineers, etc. is expected to grow. The top 5 STEM jobs in the USA include Software Developer, Statistician, Actuary, Mechanical Engineer, and IT Manager (Nguyen et al., 2020).

STEM toys are used to form and develop STEM skills from early childhood, and an entire

industry is dedicated to their development. These are robot toys, lotto, dominoes, puzzles, jigsaw puzzles, moving machines, and the like. An example of this is the high-tech robot ball, which can be controlled using a smartphone or tablet via a mobile application. The toy has a built-in gyroscope and accelerometer. This toy develops the child's hand motor skills and logical thinking (Obukhov & Lovyagin, 2020).
Specific STEM equipment has been developed for each educational field. For the mathematical educational field, LEGO construction sets can be used to create an exciting, practice-oriented educational process aimed at developing STEM competencies in school students. LEGO parts and robotic platforms help to awaken children's natural curiosity in mathematics lessons and develop the most important skills of communication, creative thinking, collaboration, and critical thinking. LEGO can be used to study parts and fractions, the arithmetic laws of addition and multiplication, etc. (Khavenson, Kotik & Koroleva, 2020).
Geometrical materials include kits for modeling 2D and 3D objects, 3D printers, 3D glasses, mobile applications for studying spatial figures, cards with augmented reality, and the like. For example, Google VR services are used to study three-dimensional figures. Based on the Cardboard application, you can create and customize your own 3D glasses, with which you can watch videos with elements of augmented reality.
To study units of measurement, models of mechanical watches, stopwatches, various scales, instruments for measuring length and width are used (rulers, slide gauges, tape-lines, compasses, protractors).
A large set of STEM equipment is also offered for the natural sciences education area: sets of models of fruits, vegetables, root crops, mushrooms, animals, sets of tables on human body structure, human skeleton, cards on anatomy with augmented reality, globe, maps, microscope, digital microscope, tellurium, nature calendar, world maps (political, physical).
In particular, "Anatomy" in augmented reality is a means by which the study of the human body becomes visual and understandable. The school student points his phone or tablet camera at the pages of the book and sees it come to life. He/she can view images from all sides, study and remember basic terms.
Consequently, there is a sufficient number of scientific developments, special digital resources, methodological recommendations and appropriate equipment for the successful implementation of STEM in the educational process.

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