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- 13.00.00 Pedagogika fanlari
- 13.00.01 Pedagogika nazariyasi. Pedagogik ta'limotlar tarixi
- 13.00.02 Ta'lim va tarbiya nazariyasi va metodikasi (sohalar bo'yicha)
- 13.00.03 Maxsus pedagogika
- 13.00.04 Jismoniy tarbiya va sport mashg'ulotlari nazariyasi va metodikasi
- 13.00.05 Kasb-hunar ta'limi nazariyasi va metodikasi
- 13.00.06 Elektron ta'lim nazariyasi va metodikasi (ta'lim sohaları va bosqichlari bo'yicha)
- 13.00.07 Ta'limda menejment
- 13.00.08 Maktabgacha ta'lim va tarbiya nazariyasi va metodikasi
- 13.00.09 Ijtimoiy pedagogika
- 07.00.00 Tarix fanlari
- 19.00.00 Psixologiya fanlari
- 01.00.00 Fizika-matematika fanlari
- 02.00.00 Kimyo fanlari
- 03.00.00 Biologiya fanlari
- 09.00.00 Falsafa fanlari
- 10.00.00 Filologiya fanlari
- 11.00.00 Geografiya fanlari

M AKTABGACHA VA AKTAB TA'LIMI

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STEM EDUCATION TECHNOLOGY: PHYSICS TEACHING METHODOLOGY AND FUTURE INNOVATIONS

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Abstract: This article examines the impact of STEM (Science, Technology, Engineering, Mathematics) education technology on the developmental stages of physics teaching methodology. The STEM approach encompasses interdisciplinary integration, the development of practical skills, and innovative teaching methods. The article analyzes the theoretical foundations of STEM education, methodological aspects, encountered obstacles, and future prospects.

Key words: STEM education, digital technologies, physics teaching methodology, educational innovations, science integration, practical education, project-based learning, virtual laboratories.

Annotatsiya: Ushbu maqolada STEM (Science, Technology, Engineering, Mathematics) ta'lim texnologiyasining fizika o'qitish metodikasining rivojlanish bosqichlariga ta'siri tadqiq etiladi. STEM yondashuvi fanlararo integratsiyani, amaliy ko'nikmalarni rivojlantirishni va innovatsion o'qitish usullarini qamrab oladi. Maqolada STEM-ta'limning nazariy asoslari, metodik jihatlari, yuzaga kelayotgan to'siqlar va kelajak istiqbollari tahlil qilinadi.

Kalit so'zlar: STEM-ta'lim, raqamli texnologiyalar, fizika o'qitish metodikasi, ta'limdagi innovatsiyalar, fanlar integratsiyasi, amaliy ta'lim, loyihaviy ta'lim, virtual laboratoriyalar.

Аннотация: В данной статье исследуется влияние технологии STEM-образования (Science, Technology, Engineering, Mathematics) на этапы развития методики преподавания физики. STEM-подход охватывает междисциплинарную интеграцию, развитие практических навыков и инновационные методы обучения. В статье анализируются теоретические основы STEM-образования, методические аспекты, возникающие препятствия и будущие перспективы.

Ключевые слова: STEM-образование, цифровые технологии, методика преподавания физики, инновации в образовании, интеграция наук, практико-ориентированное обучение, проектное обучение, виртуальные лаборатории.

INTRODUCTION

What is STEM education? At the beginning of this century, the US National Science Foundation created the STEM (Science, Technology, Engineering, Mathematics) education system to address the shortage of technical specialists in education. The term began to appear in academic publications and mass media. Since then, the development of this form of education has become one of the key strategies of US state policy. Later, due to global technological progress, it began to spread throughout the world. Research on the development and dissemination of STEM education has been reflected in many scientific sources. In particular, reports published by the US National Science Foundation have examined the importance of STEM education for national development and measures for its advancement. UNESCO's 2017 strategy, "Education for Sustainable Development through STEM", highlights the global importance and methods of teaching STEM subjects. Influential reports such as "Rising Above the Gathering Storm" (2017) and "Successful K-12 STEM Education" (2011) provide recommendations for improving the quality and widespread implementation of STEM education.

STEM is an educational model that combines natural and engineering sciences into a single, interconnected system. It involves studying subjects such as physics, mathematics, and biology within a specific curriculum and integrating them holistically into a new system. That is, school subjects are taught from the perspective of interconnection. According to scientists, such holistic learning allows problems to be considered and solved more broadly and globally, rather than in a fragmented manner by relying on a single field. This approach defines the main aspect and principle of STEM education – interdisciplinary harmony. The application of knowledge in practice and solving practical problems are other principles of this educational approach.



Creativity and innovation, critical thinking, and design work are also key features of this education because modern society needs specialists who can think creatively, make innovative decisions, adapt to changing conditions, have broad perspectives, and possess management skills.

Developing logical thinking and reasoning abilities in future physics teachers occupies an important place. Currently, special attention is being paid to the implementation of the STEM program in education by using open, flexible, individualized, and modern educational technologies based on mastery learning. By teaching physics through the STEM program, future teachers will be able to carry out their work creatively based on existing conditions and work experience, as well as expand the framework of their logical thinking.

Table 1: Development of physics teaching methodology

Traditional methods. (1900-1950)	Empirical approach. (1950-1980)	Integrative education. (1980-2010)	Digital innovation. (2010-2024+)
Theory-centred	Experiment-based	Integration of sciences	Artificial intelligence
Oral lessons	Laboratory work	Projects	Virtual laboratory
Textbook	Practical exercises	Technological tools	AI assistant
Written work	Real-life examples	Interactive lessons	Big Data analysis
Teacher: knowledge giver	Teacher: instructor	Teacher: guide	Teacher: mentor and modeler
Student: receiver	Student: performer	Student: researcher	Student: innovator and creator

LITERATURE REVIEW

STEM education is an interdisciplinary approach to learning that removes the traditional barriers separating the four disciplines of science, technology, engineering, and mathematics and integrates them into a real, rigorous, and relevant learning experience for students.

- A) Problem solving** – in STEM, students learn to analyze real-life problems and find innovative solutions.
- B) Creativity** – discoveries in science and technology often require a creative approach. STEM encourages students to apply existing knowledge to create new ideas and designs. For example, creating innovative projects in robotics or programming.
- C) Critical analysis** – analyzing data, drawing conclusions, and making evidence-based decisions is one of the main foundations of STEM. Students develop the ability to evaluate experiments and consistently analyze results.
- D) Teamwork** – many projects are completed in groups, teaching students to help each other, exchange ideas, and work collaboratively. Engineering or scientific research projects are often carried out through collaborative thinking.
- E) Independent thinking** – STEM lessons encourage students to independently search for information, conduct experiments, and form their own views. They learn to think more deeply by asking questions and seeking answers.
- F) Initiative** – developing an innovative approach and entrepreneurial spirit is another advantage of STEM. Students are taught to promote their projects, offer practical solutions, and carry out experiments with initiative.
- G) Communication** – presenting research results, defending projects, and exchanging ideas with partners all help develop effective communication skills.
- H) Digital literacy** – working with technologies, learning programming languages, and using various software programs are integral parts of STEM education. The ability to work in a digital environment is a very important skill in modern times.

What are the goals of STEM research? The goals include connecting and deepening concepts among the four disciplines, developing STEM-related skills such as critical thinking, inquiry, engineering design, and collaboration, finding solutions to important problems, contributing to the development of our high-tech world, forming personal decision-making skills, participating in civic and cultural activities, and increasing economic efficiency. Why is STEM important? The world economy is changing. Existing jobs are disappearing due to automation, while new jobs are emerging every day as a result of technological progress. The continuous development of technology is changing students' daily learning, communication, and interactions. The skills developed by students through STEM provide a foundation for them to succeed both in school and beyond.

Employers' demand for STEM qualifications and skills is high and will continue to grow in the future. Currently, 75% of jobs in the fastest-growing sectors require workers with STEM skills. STEM gives people the ability to succeed and adapt to this changing world. STEM in early childhood. Experiences gained during children's early years are very important. The role of parents as children's first teachers is crucial in creating opportunities that help them learn in a fun and safe environment. Parents can support their children by creating a home environment that sparks curiosity and encourages questioning through play. Whether at home or outside, many enjoyable activities can make learning engaging for everyone. By encouraging children to ask questions, parents help them actively participate in their own learning and better understand the world around them. When children ask questions, they develop critical-thinking skills and STEM abilities. Instead of immediately giving answers, adults should respond with alternative questions and ideas, encouraging children to search for answers and solutions independently. Schools also implement many effective strategies to engage children in STEM education.

RESEARCH METHODOLOGY

STEM is an educational model that combines natural and engineering sciences into a single, interconnected system. It involves studying subjects such as physics, mathematics, and biology within a specific curriculum and integrating them holistically into a new system. In other words, school subjects are taught from the perspective of interconnection. According to scientists, such holistic learning allows problems to be considered and solved more broadly and globally rather than in a fragmented way by relying on a single field. This approach defines the main aspect and principle of STEM education – interdisciplinary harmony. The application of knowledge in practice, namely solving practical problems, is a key feature of this educational model because modern society needs creative thinkers, innovators, adaptable individuals, and people with broad perspectives.

ANALYSIS AND RESULTS

STEM education should begin at school. Within this educational system, students learn to find solutions to problems occurring in the world. A strong understanding of science helps students better understand the environment around them. The subject of technology makes them adaptable to the digital world and the future of humanity. Engineering teaches students the principles of problem-solving, while mathematics is necessary for analyzing data, correcting errors, and finding accurate solutions. STEM combines these four areas into one integrated system and prepares specialists who can create innovations for society and find sustainable solutions to problems. In this type of teaching, emphasis is placed on mastering subjects thoroughly, solving problems, and developing logical thinking skills. STEM gives students the opportunity to succeed in school, work, and various hobbies. For example, if we think of STEM as a carpenter's toolbox filled with different tools, a child who masters STEM well can select the necessary tools from the box and create whatever they want. In other words, all sciences are important not individually, but collectively, because together they produce the expected results.

STEM prepares specialists who have mastered science, technology, engineering, and mathematics in an interconnected way, can apply their knowledge in practice, possess computer skills, and are capable of both teamwork and independent initiative. The importance of STEM subjects lies in the fact that many of today's professions may soon be performed by automated robots or become completely unnecessary. STEM prepares specialists for this future. In STEM-related professions, mastering each subject is essential. For example, an architect must know mathematics and science well to design a 10-story building. They also need to use engineering and technology to create a model of the building. The STEM teaching system is more demanding than many other educational fields because it requires balanced mastery of all four disciplines to achieve the expected results. For instance, if you want to create a robot but do not possess all the necessary skills, it would be difficult to build a robot capable of performing the intended tasks. Nevertheless, despite these challenges, learning STEM subjects remains highly interesting and engaging.

Table 2.

Country.	Number of STEM graduates.	Total graduates.	STEM share (%).	Source (year).
China	3,570,000	8,707,317	41%	UNESCO (2020)
India	2,600,000	6,046,512	43%	UNESCO (2020)
USA	568,000	4,369,000	13%	NFS (2020)
RUSSIA	561,000	1,810,000	31%	UNESCO (2019)



Iran	335,000	837,000	40%	UNESCO (2019)
Japan	214,000	1,070,000	20%	MEXT (2020)
Uzbekistan	12,500	62,500	20%	Ministry of Higher Education of Uzbekistan (2022)

CONCLUSION

STEM education technology is one of the most innovative and effective approaches in the modern education system. This educational method, through the integration of science, technology, engineering, and mathematics, allows students to acquire deep knowledge and practical skills. Today's rapidly developing technologies and increasingly complex socio-economic environment demand that students not be limited to theoretical knowledge, but also be prepared to independently acquire new knowledge, think critically, and solve problems comprehensively. STEM education technology contributes not only to the development of individual students but also to the overall progress of society. Developing innovations and new technologies, achieving advanced results in science, and enriching the economy with high technologies are direct results of STEM education. Therefore, the widespread implementation of STEM technologies in the educational process is an important condition for increasing countries' competitiveness and preparing the younger generation to meet modern requirements.

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- 13.00.00 Pedagogika fanlari
 - 13.00.01 Pedagogika nazariyasi. Pedagogik ta'limotlar tarixi
 - 13.00.02 Ta'lim va tarbiya nazariyasi va metodikasi (sohalar bo'yicha)
 - 13.00.03 Maxsus pedagogika
 - 13.00.04 Jismoniy tarbiya va sport mashg'ulotlari nazariyasi va metodikasi
 - 13.00.05 Kasb-hunar ta'limi nazariyasi va metodikasi
 - 13.00.06 Elektron ta'lim nazariyasi va metodikasi (ta'lim sohaları va bosqichlari bo'yicha)
 - 13.00.07 Ta'limda menejment
 - 13.00.08 Maktabgacha ta'lim va tarbiya nazariyasi va metodikasi
 - 13.00.09 Ijtimoiy pedagogika
 - 07.00.00 Tarix fanlari
 - 19.00.00 Psixologiya fanlari
 - 01.00.00 Fizika-matematika fanlari
 - 02.00.00 Kimyo fanlari
 - 03.00.00 Biologiya fanlari
 - 09.00.00 Falsafa fanlari
 - 10.00.00 Filologiya fanlari
 - 11.00.00 Geografiya fanlari



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