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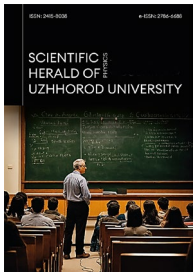

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Implementation of STEM education in the framework of the New Ukrainian School reform

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Abstract

Relevance. The research relevance is determined by the need to develop STEM education, which is envisaged by the Ukrainian government for the period up to 2027. STEM approaches are only partially implemented in Ukrainian educational institutions, mainly in out-of-school educational institutions.

Purpose. The study aims to examine the problems and the need to consider the role of STEM education technology in the process of implementing the New Ukrainian School reform at the stages of primary and senior specialised schools.

Methodology. Theoretical methods were used in the study, including analysis and synthesis, methods of generalisation, comparison and forecasting of the innovative educational process. As empirical research methods, a survey of schoolteachers in the field of STEM education was conducted.

Results. The study examines the promising areas of STEM education in the system of basic and senior specialised educational institutions. The advantages of using STEM-oriented educational programmes are outlined and the prevailing competencies for the teaching staff of the educational process are identified. The interdisciplinary connections in the implementation of STEM tasks and projects by students in various subjects were investigated. In the context of scientific work, the state of scientific and methodological support for the implementation of this technology in modern educational institutions was identified, the directions of implementation were investigated, and methods for designing STEM education into the general secondary education system were substantiated.

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Conclusions. The practical significance of the study lies in the possibility of using the obtained results in writing manuals and publishing textbooks in the direction of developing the STEM education ecosystem, and training specialists in the field of robotics in the process of teaching STEM subjects.

Keywords: learning ecosystem; digital technologies; innovative tools; organisation of the scientific process; subject; pedagogy.

Introduction

The rapid spread of innovative technologies has contributed to the emergence of new professional fields, resulting in an increased need for qualified specialists in the fields of science, mathematics, and technology. To improve the educational process, a more effective learning environment is needed: today, education plays a key role in the development of the current state of the economy in Ukraine. Today, STEM education is one of the most widespread trends in innovative education. The introduction of STEM concepts into the educational system is dictated by the requirements of the modern economy, such as strong competitiveness in the country and the international arena. Today, STEM education is the most promising and important element of innovation education around the world and therefore requires considerable attention from Ukrainian and foreign experts.

The importance of STEM education for Ukraine is reflected in the adoption by the Cabinet of Ministers of Ukraine of the Concept for the Development of Science and Mathematics Education or STEM Education in 2020 and, at the same time, raises the issue of new conditions and requirements for the quality of STEM training, which should form its own scientific and technical base of education [1]. This can be realised through the development and implementation of innovative educational tools and curricula aimed at developing cognitive skills, research skills, information analysis and processing skills, engineering skills, critical and algorithmic thinking, digital literacy, and other technical skills. Another challenge is to continuously improve the training of STEM teachers and motivate students to choose scientific and technical specialisations.

The problems of modernising the content of education in general secondary education institutions are addressed by O. Liashenko [2]. The scientist notes that in the current conditions of education reform, the actual challenge is to assess the possibilities of introducing new teaching technologies, in particular STEM education. This educational innovation involves the integration of natural sciences, technology, engineering, and mathematics. It is aimed at developing competencies in the field of exact sciences and technology. STEM education opens up new opportunities for gifted students. However, its implementation requires in-depth research of didactic and methodological principles and, the development of appropriate approaches and tools. Only a comprehensive study of the specifics of STEM education will allow its effective implementation in the educational process.

O. Buturlina [3], developer of the model curriculum for grades 5-6 and author of numerous scientific papers in the field of STEM, notes that STEM education is a response to the challenges of modern technological development and the need for qualified personnel for innovative industries. The integration of natural sciences, technology, engineering, and mathematics in the educational process is aimed at training a new generation of technical specialists. The introduction of STEM allows students to develop scientific thinking, research skills, and technological literacy. This meets the needs of economic development and labour market requirements. STEM education is a priority area of the state educational policy to ensure the country's technological leadership.

A. Ovchatova [4] studied the issue, analysing the state of implementation of STEM education in secondary education institutions in Ukraine. The author concluded that changes in the education sector in this area involve the definition of a state policy that considers such vectors as the improvement of professional skills, assessment systems and educational programmes, information and communication technologies, and research and resource provision. I. Shymkova *et al*. [5] addressed the issue of technological and professional-pedagogical training in the field of STEM education, updated and identification of key problems in the training of modern teachers, and concluded that the key idea of STEM education is to build an interdisciplinary basis for the educational and cognitive process of studying specific problem situations in real life.

N.V. Morse [6], in her scientific presentation on the problems and prospects of STEM education, noted that STEM education is based on an integrated approach to teaching the exact sciences. She combined research methods, project activities, and modelling for deep knowledge acquisition. The key elements of STEM are the practical application of knowledge, laboratory assignments, computer modelling, and design. Students learn to analyse data, draw conclusions, and create interactive models. STEM involves openness to new knowledge and the development of critical and systemic thinking. Through the integration of natural sciences, technology, engineering and mathematics, students gain a holistic view of the phenomena under study.

S. Dotsenko [7] addressed the implementation of STEM education in primary and basic schools, arguing that future economic growth significantly depends on the availability of qualified STEM specialists and scientists, whose formation and specialisation should begin at the stage of primary, and later basic and specialised schools through the active implementation of STEM education. Furthermore, the author suggests that the development of the STEM system should be supported by the introduction of new educational disciplines, courses and electives based on the wide involvement of students in educational discovery. On the other side, Yu.Yu. Matviichuk [8], analysing STEM education as a tool for implementing the integrated study of natural and mathematical disciplines, defines the STEM system as a pedagogical technology and as the main means of reforming the modern educational system of Ukraine.

It is possible to conclude from a range of modern studies that contemporary authors, studying the implementation of STEM education in modern conditions,

devote much less attention to the role of STEM technologies in the process of implementing the NUS reform at the stage of primary and senior secondary schools, and the necessary scientific and methodological support. Thus, the promising goal of the study is to analyse the resources for organising STEM lessons for students of primary and senior specialised schools, as well as ways to introduce the latest teaching methods.

Materials and Methods

The following theoretical methods were used in the study: analysis and synthesis of state education standards, scientific and methodological literature, works of contemporary authors in the field of pedagogy; methods of generalisation to determine the features of STEM education technology in basic and senior specialised schools; method of comparison and forecasting of the innovative educational process. The empirical methods of the study included an online survey of schoolteachers on the implementation and improvement of STEM education. The research was carried out based on the scientific and analytical principles of systematicity, objectification, analytical comparison, comprehensive systemic aspects, and approaches. To study the scientific resources in detail, the study used the method of analysis and synthesis. The method of comparison of elements and generalisation was used to identify key theoretical positions, classify approaches and views on the described issues, and understand the basic concepts in the context of the research.

The survey was conducted using the Google platform. The survey involved 75 teachers of various disciplines from 3 general secondary schools in Kyiv, Odesa and Ternopil regions and 3 senior specialised schools in Kyiv, Lviv and Chernihiv regions. The survey included 8 multiple-choice questions and 1 open-ended question about the implementation and strategy of STEM education, existing and possible suggestions for improvement, the effectiveness of the STEM system, teacher training, and the use of innovative technologies. The Google form included the following questions: availability of teachers in the field of natural sciences, mathematics, technology, engineering, and art; training and professional development of teachers; use of innovations and interactive methods; provision of equipment for natural and mathematical classrooms and research laboratories; availability of science and mathematics classrooms and research laboratories; career guidance activities and weeks to promote STEM education; choice of teaching methods and communication with students; consistency of the STEM approach with the requirements for the educational process in the New Ukrainian School (NUS) reform; proposals for improving the quality of STEM education.

The methodological basis of the research includes scientific provisions of theories of cognition about the interaction of environmental processes and phenomena in the present-day conditions, considering the socio-cultural level, cultural and historical process of the education system; provisions of the concept of systematic analysis of practical and theoretical processes of pedagogy; scientific principles of integrity and objectivity that combine historical, economic, social, cultural, political, professional and other educational qualities; perception of school education as a key element of innovative processes, recognising it through the prism of phenomenality, which has a much more effective impact on the development of the student and teacher.

The research materials were based on regulatory and legislative documents on the development of Ukrainian education, including the Law of Ukraine No. 960-p "On the approval of the Concept of the development of science and mathematics education (STEM education)" [9], Methodological recommendations for the development of STEM education in institutions of general secondary and extracurricular education in the 2023/2024 academic year [10], Law of Ukraine No. 31 "On complete general secondary education" [11], Law of Ukraine No. 38-39 "On education" [12]. The study also analysed various Ukrainian and global scientific resources that define strategic priorities that contribute to the development of primary and senior specialised schools: declarations, theses, scientific reference books, resolutions; scientific printed resources: dissertations, monographs, scientific articles, books; electronic sources of national libraries, research institutions and leading Ukrainian educational institutions. The integrated use of these methods has made it possible to formulate several scientific proposals for improving the state and overall development of STEM education in Ukrainian schools.

Results

The NUS reform was launched in 2018 and has become one of the key initiatives of the Ministry of Education and Science in recent years, which is expected to last for a long period. The main goal of this reform is to organise the educational process in Ukrainian schools where students will learn effectively and, most importantly, be able to apply the knowledge gained in the learning process in their everyday and professional lives. An important tool of the NUS reform is the latest information and communication technologies (ICTs), the widespread use of which allows to optimise educational processes and expand the range of opportunities for teachers and students, developing their professional and personal competence skills [13].

The New Ukrainian School positions itself as one that recognises the opinions and ideas of its students, teaches them to think critically, express their opinions and be responsible citizens, and creates an atmosphere of cooperation and mutual understanding. The implementation of the NUS promotes significant changes. It involves students acquiring new competencies instead of simply memorising concepts and facts. This is a dynamic combination of skills, knowledge, attitudes, values, ways of perception, and other personal characteristics that reveal a person's propensity for successful socialisation, and educational and professional activities. In this way, a range of knowledge and skills is formed, which are superimposed on the ability to use the acquired knowledge, as well as skills and values that will be useful to graduates of the new Ukrainian school in their professional and private lives. The Law of Ukraine No. 38-39 "On education" sets out a list of competencies that students at the New Ukrainian School will acquire [12]. They include fluency in the state and foreign languages, mathematical, environmental,

cultural, information and communication competence, competence in natural and mathematical sciences, and technological and innovation competence. They also develop civic and social competencies to promote the idea of democracy, justice, protection of personal rights, equality, goodwill, and healthy lifestyles, with an understanding of equal opportunities and rights, and the list also includes entrepreneurship and financial literacy. Common to all competencies is the so-called cross-cutting skill, namely, competent reading, the ability to express personal vision and opinion both in written and oral forms, systematic and critical thinking, correct proposal formulation, initiative, ability to control personal emotions, assessment of possible risks, decision-making, solving situational tasks and problems, teamwork, and communication with peers [14].

The introduction of project-based, integrated and STEM-oriented learning helps students to perceive the world more globally, as they study environmental phenomena from the perspective of different sciences and learn to solve problems that may arise in real life through the study of various subjects using innovative methods. Thus, the modernised assessment model is based on the formed assessment, which renders a conclusion on the learning process, and not only on the result based on the number of mistakes made by the student. Changes in the educational environment are focused on changes in attitudes towards students, namely in showing due attention, respect, and the desire to find the best way to teach them effectively, which is what characterises the New Ukrainian School [15].

One of the most important principles of the New Ukrainian School is the proper motivation of teachers. To teach in a new way, and to have the skills of the STEM system, teachers must be given full freedom of action in choosing interactive learning materials, improvisation, and experimentation. The key principle of the NUS is cooperation and partnership, the relationship between the school and parents, which is why the school creates a framework of public self-government with the participation of parents, as a result of which they are free to influence the educational and upbringing processes. Creating conditions that facilitate successful cooperation between all participants in the educational process, i.e., teachers, students, school management, partners, and parents, is the first aspect in achieving all other results. In this way, it is possible to achieve the main goal, which is to improve the educational environment and implement learning for life [16].

As for STEM approaches in the organisation of the educational process, proper attention is devoted to science, technology, engineering, mathematics, and innovation. Some educational programs add literature, art, music and reading to these subjects. STEM education has basic postulates, which primarily include practice, in which students have the opportunity to perform specific tasks that allow them to better perceive and master theoretical material. An important place is occupied by the research approach, when students observe how various processes take place in the laboratory or, for example, in the field. At the next stage, the role of visualisation tools is crucial, as they help students to learn how to present ideas, and suggestions and formulate tasks. The process of teamwork is essential, as children develop personal organisational and communication skills while completing a team project. The study of engineering, natural sciences, and cause-and-effect relationships by students is important for dynamic development in the context of rapid innovation [17].

STEM education contributes to better material learning, increasing students' interest in lessons and the educational process in general. One of the most important tasks is to develop students' creative thinking and perception. In general, the interaction of the latest tools and the study of various disciplines helps students to perceive phenomena from a global perspective. The ability to quickly adapt to trends and techniques is crucial in the new educational and professional markets. STEM education is based on a systematic and active approach and independent scientific and research activities of students. The STEM approach to learning is widely used in schools today, but teachers often use the term project-based learning about STEM education. The creation of individual or team projects by students, work on their improvement and originality involves multidisciplinarity. With this approach, children apply knowledge from a variety of fields: mathematics or other exact sciences, design, engineering, and use digital devices and other technologies. STEM education is a universal practice-oriented approach that enables students to solve problems of varying complexity. At the same time, children receive practical implementation of the knowledge gained in the educational process [18].

STEM education in general secondary education is implemented through public or private schools, commercial centres that focus on original proposals to prepare students for real adult professional life; through experimental and research projects, in which the latest tools are created and used, teacher training is organised, and new ideas and practices are disseminated; through the support of companies that manufacture and sell relevant innovative equipment and technologies for school laboratories; and through the initiatives of individual teachers and school groups in search of the latest tools and techniques needed in their activities [19].

In Ukraine, STEM education is regulated by several measures prescribed in the Concept of Development of Science and Mathematics Education (STEM education) until 2027, the main directions of which are the organisation and holding of events such as conferences, tournaments, quizzes, some of which are organised for pedagogical training of educational process workers on the use of trend methods of science and mathematics education, as well as to create STEM centres and conduct research on STEM education [9]. It is possible to assume that STEM education will be able to achieve results when it acquires the status of a pedagogical technology or a so-called didactic system that clearly defines its purpose, identifies the features of didactic principles, and organizes the purpose of education depending on the choice of areas. Regarding the curriculum and its content, it is necessary to choose a specific strategy for learning and its form, to formulate requirements for the organisation of the educational process. This creates an environment in the educational system that contributes to the achievement of high results for students in the fields of mathematics,

technology, science, and information education of the state standard of basic secondary education [20].

As part of the study, an online survey was conducted with 75 teachers of various disciplines from 3 general secondary education schools in Kyiv, Odesa and Ternopil regions and 3 senior specialised schools in Kyiv, Lviv and Chernihiv regions on the implementation, existing and possible proposals for improvement, effectiveness of the STEM system, pedagogical training, and application of innovative technologies (Table 1).

Table 1. Quality of STEM system in NUS

Question No.	Study element	Primary school	Senior specialised school
1	Availability of teachers in natural sciences, mathematics, technology, engineering, art	Kyiv and Odesa regions: schools have qualified teachers in the relevant disciplines; Ternopil region: schools have qualified teachers in natural, mathematical, technological, and creative disciplines	Specialist schools in these areas have highly qualified teachers in these disciplines
2	Level of training and professional development of teachers	Regular tests to determine the level of competence of teachers and activities to familiarise them with STEM education methods and materials are held at the primary school	Teacher training activities in STEM education are held at the level of senior specialised schools, additional courses are provided, and regular tests are conducted to assess the competence of the teaching staff
3	Use of innovations and interactivity	During the classes, interactive tools (maps, presentations) are used, diverse practices are carried out through digital technologies, innovative methods of the educational process	During the classes, interactive tools (maps, presentations) are used, and diverse practices are carried out through digital technologies and innovative methods of the educational process. Appropriate innovative equipment is used in specialised technical and natural science and mathematics classrooms
4	Provision of equipment for science and mathematics classrooms and research laboratories	Classrooms are equipped with the latest equipment and digital technologies	Classrooms are equipped with a full range of the latest specialised equipment and digital technologies
5	Availability of natural and mathematical classrooms and research laboratories	Availability of classrooms that can be adapted to natural and mathematical practices, technological classrooms, availability of creative classrooms	Availability of specialised natural science, mathematics, research, and creative classrooms
6	Holding career guidance events and weeks to promote STEM education	Career guidance activities to promote STEM education are held at pedagogical, parental and student meetings	Career guidance events and weeks to promote STEM education are held with the participation of all participants in the educational process
7	Choosing teaching methods and communication with students	Communication with students takes place through practical, multifaceted classes on solving situational problems and projects	Communication with students takes place through practical, multifaceted classes on solving situational problems, individual and creative projects
8	Consistency of the STEM approach with the requirements for the educational process in the NUS reform	The conditions of STEM education fully meet the requirements of the NUS, as it introduces innovation, and competence in natural-mathematical, engineering, creative, technical, and other areas, spreads the ideas of equality, justice, opportunity and trust, and forms cultural competence	
9	Suggestions for improving the quality of STEM education	Creation of specialised state-of-the-art laboratories, involvement of specialists to create additional courses in STEM education at the primary school level	At this stage of functioning, the senior specialised school, according to the NUS reform, adheres to the STEM concept

Source: compiled by the authors.

Based on the results obtained, insignificant differences in the qualitative level of STEM education development in basic and senior specialised Ukrainian schools can be observed. Some elements that characterise the quality of

STEM education need to be improved at the basic school level: specialised equipment for science and mathematics laboratories in basic and senior specialised schools; the creation of databases, the use of interactive tools that contribute to the effective implementation of science and mathematics or STEM education, and their regular modernisation; career guidance activities for students to promote the STEM education system in the form of professional future projects and weeks dedicated to STEM topics and main trends. The use of modern technologies in STEM education focuses on the problem of the professional development of teachers in this area, and their skills in managing the educational process, which is dominated by the structure of the subject and is more staffed than the discipline it teaches. The practical rating of STEM education implementation includes elements such as team, individual, creative and other projects; combining natural, information, mathematical, technological, literary, historical, and artistic sciences in the structure of educational information; working on research tasks using innovative digital technologies within the educational process; designing the latest digital and material models and products; and introducing integrated classes into the educational system. In this way, an educational environment should be formed in which high learning outcomes in the mathematical, natural, technological and information education areas of the state education standard of primary and senior specialised schools will be achieved.

Discussion

The world is changing rapidly, and modern schools must follow educational and innovation trends. The main task of an educational institution is to prepare students to work with information, critical thinking, analysis and, in general, to the conditions of adult professional life. The focus on memorisation of a certain amount of knowledge in the classical educational approach is less effective today. In the absence of relevant skills, abilities and competencies that are key in the professional market, it becomes more difficult to expect educational and professional success. STEM education contributes to the development of these characteristics.

STEM education is a completely new system, the application of which is a necessity in the modern world, which can prepare all participants in the educational process to be experts in the field of natural sciences, mathematics, and technology [21-23]. It is very important to prepare the next generation to meet the challenges of the STEM system. A study conducted by R. Tytler [24], which examined the main trends and overall importance of STEM education in the 21st century, found that 74% of students who completed their STEM education programmes considered poor teaching to be the main obstacle. The author found that the level of teacher's knowledge of their subject corresponds to the quality of student learning. The study also showed that an increase of one mathematics course for a teacher with less mathematical training was associated with a 1.2% increase in primary school students' performance, but that the addition of additional courses for teachers has a positive impact on student achievement in various disciplines. It is worth agreeing with the author's assumptions, since the training and retraining of a teacher who not only carries out teaching activities but also shows the ability to build interdisciplinary connections and understands the importance of the acquired professional knowledge through the prism of the socio-cultural space. The teacher's skills to organise learning as a relationship between all participants of the educational process focused on the development of the personal qualities of the student are important.

C. Johnson *et al*. [25] noted in their book on STEM education that it is important to who teaches and what innovative methods they use. The authors argue that a typical primary school teacher with minimal training in any area of STEM education is usually not confident in their subject knowledge, which can affect students' perception of it. The results coincide, as it has been determined that STEM education is a vector for implementing teacher innovation and an integrated approach to the educational process, in which concepts in technology and science are considered through real-life conditions, as well as to recreate sustainable links between the educational institution and the public [26; 27].

E. McLoughlin *et al*. [28], studying the peculiarities of implementing STEM education for primary school, argue that it is designed in such a way that it provides an opportunity for students to successfully analyse specific situations and develop their views in solving various kinds of issues. They also have the opportunity to find answers not in theoretical materials, but in the process of practical exercises, making mistakes and correcting them. In addition, STEM education helps to fully engage the student in the learning process and to reveal the creative capabilities of each child personally. For example, in primary schools, STEM education focuses primarily on cooperation, communication, creativity, and imagination [29; 30]. It is worth agreeing with this statement, because comparing the authors' results with the results obtained in the course of the study, it can be assumed that education in both primary and secondary schools allows students to think consciously and creatively and express personal visions on the proposed topics, which also presents STEM education as a valuable component and key element of the New Ukrainian School reform.

T. Nguyen *et al*. [31] refer in their research to the study of STEM education in secondary schools and teachers' views on sustainable development that the introduction of innovative education in line with European standards is aimed at training the newest generation, meeting the requirements of social modern mobility, and understanding the latest technologies. Scientists also promote the idea that the exclusive model of cross-cutting STEM education in schools is to conduct integrated classes to build interdisciplinary relationships that influence the formation of a global systemic view of the world by students, as well as to actualise personal attitudes to the issues discussed in the classroom. It is worth comparing the conclusions of these authors with the results obtained since the study found that the use of STEM educational principles in the NUS learning environment has influenced the creation of a clear innovative teaching methodology with new proposals for opportunities for both students and teachers. By applying a practical orientation, research and project activities during lessons, an interdisciplinary approach,

integration of academic disciplines, and focus on STEM concepts, a modern, economical, stable, technologically high-quality, and intelligent society is being built.

J. Morris *et al*. [32] argue that national science standards and variations in STEM disciplines should be closely scrutinised by experts and academics. To ensure highly qualified teachers, science standards should be written in a way that is more cross-cutting and includes more scientific reasoning and concepts. Researchers argue that the ambiguity of contradiction should be avoided when it comes to standards for STEM disciplines, which can lead to a focus on one particular area. It is also essential to consider the adoption of national standards in each country, which guide the education system on the choice of programmes and STEM activities. This statement coincides with the results obtained since the curriculum standards used by teachers in STEM education are a cognitive artefact based on a conceptual ideal model identical to the concept of design, a design model that complements the conceptual model and merges into a constructive-creative methodology, thus combining theory and practice [33-36].

Education in the modern world cannot function effectively without considering the requirements of the reforms currently underway around the world, including in Ukraine. In the concept of secondary education, STEM aspects are perceived as the alignment of educational programmes and the implementation of integrated lessons [37; 38]. Nowadays, in global educational practice, it has acquired more technological content and corresponds to the concept of pedagogical technology. The means of achieving the goals of STEM education correspond to the methods and forms of teaching, educational tools, and approaches in the context of learning outcomes assessment. Considering such evolutionary processes of our time, which correspond to the Ukrainian educational system, it is possible to state that they focus on the need for support at different stages, and the creation of specific pedagogical technologies for STEM education [20; 39].

Scientists studied the problems and prospects of STEM concepts in education, identified the peculiarities of using technology in STEM project activities, and identified the problem of teacher training in STEM. Also, the practical aspects of implementing STEM education in schools remain insufficiently researched. The latest information and communication technologies (ICTs) are an important tool of the NUS reform, as their widespread use allows to optimise education processes and expand the range of opportunities for teachers and students, developing their professional and personal competence skills [40]. Currently, STEM education is a key and very promising element of implementing innovation in the educational space around the world, which aims to prepare children to use the skills and knowledge they have acquired correctly to solve problems in their professional activities, to improve highly organised critical thinking, and to develop STEM competencies [41; 42]. However, the problem of the effectiveness of STEM education requires research intervention and a detailed study of its features and prospects.

Conclusions

The STEM system is an innovation for modern education, the application of which is a necessity in today's conditions and creates conditions for all participants in the educational process to be experts in the field of natural sciences, mathematics, and technology. At the same time, one of the prevailing concepts of the New Ukrainian School is the ability to motivate teachers. To teach according to trends and, accordingly, to master the skills of the STEM system, a qualified teacher must be given full freedom of action in choosing educational interactive materials, improvisation, and experimentation. In this regard, the key stage is to prepare the younger generation to meet the challenges of STEM education.

In the context of primary school, STEM education is tasked with developing a strong interest in science and mathematics subjects and providing a range of professionally important skills and knowledge that will be needed in future activities, including in the technical and innovation industry in general. Participation of students in research, creative, inventive activities, integrated classes, thematic events, practical training, interdisciplinary project work, professional STEM courses, competitions, festivals, clubs will help to increase the percentage of students who see themselves in research in the future, assess their capabilities and talents. This will increase the level of students' awareness of the STEM subjects and STEM professions offered, as well as academic conditions in various professional fields. At the level of a senior specialised school, STEM education aims to help students make a conscious choice about their future speciality in the context of a STEM profile, receive quality training in several STEM disciplines and master professional scientific methodology.

At the junior and senior high school level, important elements that characterise the quality of STEM education need to be modernised, such as specialised equipment for science and mathematics laboratories in schools to ensure productive work; the creation of databases and the use of interactive maps and other tools that affect the effective implementation of science and mathematics or STEM education, and their regular updating; organisation of career guidance activities for students to promote the STEM education system in the form of professional and scientific future projects. The use of innovative technologies in STEM education focuses on the problems of teacher training in this area and their abilities to manage the learning process.

Further research could be conducted on the possibility of applying the recommendations obtained based on the survey to write manuals and publish publications on the development of modern education in educational institutions of various types.

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Conflict of Interest

None.

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Впровадження STEM-освіти в рамках реформи Нової української школи

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Анотація

Актуальність. Актуальність дослідження зумовлена необхідністю розвитку STEM-освіти, яка передбачена урядом України на період до 2027 року. STEM-підходи лише частково впроваджуються в українських закладах освіти, переважно в позашкільних навчальних закладах.

Мета. Метою дослідження є вивчення проблем та необхідності врахування ролі технологій STEM-освіти в процесі впровадження реформи Нової української школи на етапах початкової та старшої профільної школи.

Методологія. У дослідженні використано теоретичні методи, зокрема аналіз і синтез, методи узагальнення, порівняння та прогнозування інноваційного освітнього процесу. Як емпіричні методи дослідження було проведено опитування шкільних вчителів у сфері STEM-освіти.

Результати. У дослідженні розглядаються перспективні напрями STEM-освіти в системі базових і старших профільних навчальних закладів. Окреслено переваги використання STEM-орієнтованих освітніх програм та визначено головні компетенції для педагогічного персоналу освітнього процесу. Досліджено міжпредметні зв'язки при виконанні STEM-завдань і проєктів учнями з різних предметів. У контексті наукової роботи визначено стан науково-методичного забезпечення впровадження цієї технології в сучасних закладах освіти, досліджено напрями впровадження та обґрунтовано методику проєктування STEM-освіти в систему загальної середньої освіти.

Висновки. Практичне значення дослідження полягає у можливості використання отриманих результатів при написанні посібників та виданні підручників у напрямку розвитку екосистеми STEM-освіти, а також при підготовці фахівців у галузі робототехніки в процесі викладання STEM-предметів.

Ключові слова: навчальна екосистема; цифрові технології; інноваційні інструменти; організація наукового процесу; предмет; педагогіка.