



UDC 373.5

[https://doi.org/10.52058/2786-6165-2024-7\(25\)-576-588](https://doi.org/10.52058/2786-6165-2024-7(25)-576-588)

Sipii Volodymyr Volodymyrovych PhD in Pedagogics, Head of the Department of Biological, Chemical and Physical Education, Institute of Pedagogy of the National Academy of Educational Sciences of Ukraine, 52-D Sichovyh Streltsiv St., Kyiv, 04053, <https://orcid.org/0000-0003-4825-1426>

EVALUATION OF STATE POLICY IN THE FIELD OF INNOVATION SUPPORT IN STEM EDUCATION IN UKRAINE

Abstract. The purpose of the article was to analyse and evaluate the state policy in the field of STEM education in Ukraine. To achieve the goal, a comprehensive approach was used, which included the analysis of scientific works and regulatory acts, comparative analysis and generalisation of the obtained data. As a result of the research, it was found that STEM education is one of the directions of the implementation of innovative activities in educational institutions of Ukraine. Educational methods and programmes of STEM education are focused on the development of key competences that are important in the modern labour market. These competencies include critical thinking, engineering thinking, the ability to develop and implement algorithms to solve problems, the ability to effectively collect, process and analyse large volumes of data, and digital literacy. The Government of Ukraine, realising the importance of the development of STEM education, actively supports the implementation of this direction. This is confirmed by a number of important steps and the adoption of a number of legislative acts. An important step on the way to large-scale innovation was the adoption of the Concept of the Development of STEM Education for 2020-2027 in Ukraine. Successful examples of the implementation of STEM education ideas in Ukraine are analysed. It was determined that Ukraine already has a global approach to STEM education at the national level. This approach includes a number of initiatives aimed at developing STEM competencies and encouraging young people to pursue STEM research. One of these initiatives is the creation of regional and local STEM centres. Under the conditions of martial law in Ukraine, the use of artificial intelligence becomes especially relevant. This innovation can help preserve and develop the country's intellectual resources. The implementation of artificial intelligence and other modern technologies in STEM education of Ukraine has the potential to make a significant contribution to improving the quality of education, developing



innovative potential, and training competitive specialists. In general, the main strategic directions of state support for STEM education are aimed at the development of critical thinking, engineering skills and digital literacy among young people. However, despite a number of successful programmes and initiatives aimed at developing STEM education, the effectiveness of their implementation is often limited by insufficient funding, the lack of modern STEM laboratories, and certain shortcomings in teacher training. An important aspect is the need to intensify cooperation between public and private educational institutions, business and communities to create a sustainable educational ecosystem.

Keywords: STEM education, investments, educational technologies, provision of scientific potential, analysis of state initiatives.

Сіній Володимир Володимирович к. пед. наук, завідувач відділу біологічної, хімічної та фізичної освіти, Інститут педагогіки Національної академії педагогічних наук України, вул. Січових Стрільців, 52-Д, м. Київ, 04053, <https://orcid.org/0000-0003-4825-1426>

ОЦІНКА ДЕРЖАВНОЇ ПОЛІТИКИ В ГАЛУЗІ ПІДТРИМКИ ІННОВАЦІЙ У STEM-ОСВІТІ В УКРАЇНІ

Анотація. Метою статті було проаналізувати та оцінити державну політику у галузі STEM-освіти в Україні. Для досягнення поставленої мети було використано комплексний підхід, який включав аналіз наукових праць та нормативних актів, порівняльний аналіз та узагальнення отриманих даних. У результаті дослідження було з'ясовано, що STEM-освіта є одним з напрямків впровадження інноваційної діяльності у навчальних закладах України. Навчальні методики та програми STEM-освіти орієнтовані на розвиток ключових компетентностей, які є важливими на сучасному ринку праці. Ці компетентності включають критичне мислення, інженерне мислення, здатність розробляти і реалізовувати алгоритми для вирішення задач, вміння ефективно збирати, обробляти і аналізувати великі обсяги даних, цифрову грамотність. Уряд України, усвідомлюючи важливість розвитку STEM-освіти, активно підтримує впровадження даного напрямку. Це підтверджується рядом важливих кроків та прийняттям низки законодавчих актів. Важливим кроком на шляху до широкомасштабної інновації стало прийняття Концепції розвитку STEM-освіти на 2020-2027 роки в Україні. Проаналізовані успішні приклади реалізації ідей STEM-освіти в Україні. Визначено, що Україна вже має глобальний підхід до STEM-освіти на



національному рівні. Цей підхід включає низку ініціатив, спрямованих на розвиток компетенцій у STEM і заохочення молоді до STEM-досліджень. Однією з таких ініціатив є створення регіональних та місцевих STEM-центрів. В умовах воєнного стану в Україні особливо актуальним стає використання штучного інтелекту. Ця інновація може допомогти зберегти та розвивати інтелектуальні ресурси країни. Впровадження штучного інтелекту та інших сучасних технологій в STEM-освіту України має потенціал зробити значний внесок у підвищення якості освіти, розвиток інноваційного потенціалу та підготовку конкурентоспроможних фахівців. Загалом, основні стратегічні напрями державної підтримки STEM-освіти спрямовані на розвиток критичного мислення, інженерних навичок та цифрової грамотності серед молоді. Проте, незважаючи на низку успішних програм та ініціатив, спрямованих на розвиток STEM-освіти, ефективність їх реалізації часто обмежується недостатнім фінансуванням, відсутністю сучасних STEM-лабораторій та певними недоліками у підготовці педагогів. Важливим аспектом є необхідність активізації співпраці між державними та приватними освітніми установами, бізнесом та громадами для створення стійкої освітньої екосистеми.

Ключові слова: STEM-освіта, інвестиції, освітні технології, забезпечення наукового потенціалу, аналіз державних ініціатив.

General statement of the problem and its connection with important scientific or practical tasks. One of the tasks of modern educational institutions is to unleash the potential of all participants in the educational process and provide them with opportunities to show their creative abilities. Achieving this goal is impossible without the introduction of variability in educational processes, which leads to the emergence of various innovative activities in the educational process that require deep scientific and practical understanding.

Analysis of recent research and publications. The issue of state policy in the field of innovative development of STEM education has been partially considered in different contexts by domestic scholars. Thus, the experience of implementing STEM education by Ukrainian educational institutions was considered in the work of N. Donets [1], V. Rohosa [2], T. Yarmolenko [3], N. Honcharova [4], L. Hrynevych [5] and other scholars devoted their research to the formation of the STEM education ecosystem in the context of the labour market transformation and the risks posed by the fourth industrial revolution.

Based on the study, the authors identified groups of digital tools that are necessary for the development of the ecosystem and will help to improve the



effectiveness of STEM education [5]. M. Komar emphasised that innovation is an important aspect of the modern education system [6]. B. Malitsky, in turn, stressed that the state of the economy, welfare, national security of the country, as well as its international position in the modern world directly depend on the level of development of national science and the ability to use the latest scientific achievements and high technologies in social, economic and military practice on a large scale [7]. STEM education is a field of training specialists who can apply scientific achievements and high technologies in various spheres of life.

Identification of previously unresolved parts of the overall problem.

A review of recent scientific works has shown that government initiatives in the process of introducing innovations in STEM education are not yet fully understood.

Formulation of the objectives of the article (statement of the task).

The purpose of the article is to analyse the state policy in support of innovations in STEM education in Ukraine to assess its effectiveness and identify problematic aspects. The objectives of the article are:

- to analyse the features of STEM education as one of the innovative areas;
- identify the main areas of state support for STEM education in Ukraine;
- identify key challenges and obstacles to the implementation of STEM education in Ukrainian educational institutions.

Presentation of the main research material with full justification of the scientific results obtained. One of the ways to develop educational institutions is through innovation, which encourages teachers to create and disseminate new educational products. A pedagogical innovation is a new product, the result of the process of creating something new that updates pedagogical theory and practice, ensuring the achievement of educational goals. One of the areas of innovation in an educational institution is STEM education. STEM is a popular area of education that includes natural sciences, technology, engineering and mathematics. It is an educational approach based on interdisciplinarity and an applied approach, where the natural science component is strengthened and innovative technologies are introduced.

In Ukraine, STEM education is gaining more and more recognition every year. The Government of Ukraine, recognising the importance of STEM education, actively supports the implementation of this area. This is evidenced by a number of important steps and the adoption of a number of legislative acts that promote the effective implementation of STEM education, in particular in general secondary education institutions. The state policy in the field of education in Ukraine is a component of the national policy, which includes a set of goals, objectives, principles, programmes and main activities of educational authorities.



This policy is aimed at organising scientific and methodological support for the development strategies of the educational system and is based on strategic documents for the development of education. For example, on 5 August 2020, the Cabinet of Ministers of Ukraine approved the Concept for the Development of Science and Mathematics Education (STEM education), which should be implemented by 2027 [8]. This Concept is aimed at modernising STEM education and implementing it on a large scale at all levels of education, establishing partnerships with employers and research institutions, and involving them in the development of science and mathematics education. According to the Concept of STEM education, teaching methods and programmes are focused on the development of key competences that are important in the modern labour market. These competences include:

- 1) critical thinking;
- 2) engineering thinking;
- 3) ability to develop and implement algorithms to solve problems;
- 4) Ability to effectively collect, process and analyse large amounts of data;
- 5) digital literacy;
- 6) creativity and innovation;
- 7) ability to communicate effectively and work in a team.

The competence-based approach to education reflects the phenomenon of internationalisation of world education. Critical thinking is a universally recognised competence, the development of which is necessary for Ukrainian students due to the globalisation of the labour market, informatisation and the development of civil society. Critical thinking allows students to identify problems and find ways to solve them, think independently, adapt successfully, show impartiality, curiosity and flexibility of thinking [6].

Other important legislative acts that contribute to the effective implementation of STEM education in Ukraine include:

- The Concept for the Implementation of the State Policy in the Field of General Secondary Education Reform for the Period up to 2029 “New Ukrainian School”, approved by the Cabinet of Ministers of Ukraine on 14 December 2016, No. 988-p. [9];
- Order of the Ministry of Education and Science of Ukraine No. 188 of 29.02.2016 “On the establishment of a working group for the implementation of STEM education in Ukraine” [10];
- Letter of the Institute for the Modernisation of Education Content dated 01.08.2023 No. 1242 “Methodological recommendations for the development of STEM education in general secondary and out-of-school education institutions in the academic year 2023/2024”;



- Order of the Ministry of Education and Science of Ukraine No. 574 of 29.04.2020 “On Approval of the Standard List of Teaching Tools and Equipment for Classrooms and STEM Laboratories” [11].

During the years of Ukraine's independence, spending on general research and scientific support for key industries that ensure the country's economic development and national security has been rapidly declining [7]. The Ukrainian government's priority attention to STEM education is understandable, as, firstly, the losses caused to the Ukrainian economy by Russian aggression require extraordinary efforts to eliminate them, especially in the area of national infrastructure restoration. One of the main threats to the Ukrainian economy is the significant deterioration of the country's scientific potential.

The importance of developing scientific potential to enhance global competitiveness, economic independence and security is driven by the need to create own scientific developments and implement them in the innovative industrial sector, the need to generate new knowledge to ensure innovative development [12]. This creates a need for specialists capable of integrated scientific and engineering activities. Secondly, significant interest in STEM education is caused by its innovative nature, in particular in creating an effective model of cooperation between educational institutions, the state and business [2].

Since 2015, the STEM Education Department of the State Scientific Institution “Institute for the Modernisation of Education Content” has been coordinating the activities of scientists, teachers and specialists in STEM education. Scientists of the department are involved in the development of conceptual, regulatory, scientific and methodological foundations of STEM education. To share experiences, a Facebook group has been created to host various activities for teachers and researchers. An example of such an activity is the annual STEM Spring Festival of Ideas and Projects, which publishes collections of the best projects.

The STEM Education Department was established in 2022 at the Institute of Pedagogy of the National Academy of Educational Sciences of Ukraine to provide theoretical and methodological support for the digitalisation of general secondary education and the introduction of STEM in Ukraine. The department is conducting an applied research study “Scientific and Methodological Support for the Implementation of STEM Education Technology in Gymnasiums”. In the course of the research, scientists substantiate the didactic and methodological principles of designing and implementing STEM education, developing its teaching and methodological support.



Based on the accumulated experience of implementing STEM education, the Cabinet of Ministers of Ukraine adopted the Concept for the Development of Science and Mathematics Education (STEM Education) and the State Standard of Basic Secondary Education in 2020. In 2021, based on these conceptual regulatory documents, a Model Curriculum for grades 5-9 was developed, which is being implemented gradually starting in the 2022-2023 academic year. Among the model curricula is a programme of an intersectoral integrated STEM course that involves the integration of natural, technological, informational and social sciences.

Implementation of STEM education in Ukraine requires updating the existing material and technical base. STEM centres and laboratories are being set up in educational institutions of different levels that are equipped with such facilities and have the appropriate specialists to organise research and development activities. Regional STEM centres in Ukraine are funded annually by the state to the tune of UAH 900 million. Local STEM laboratories are created on the basis of general secondary and out-of-school education institutions, at the expense of local budgets and grant support [3].

One of the key centres that successfully implements STEM education is the National Centre of the Junior Academy of Sciences of Ukraine. Members of the Junior Academy of Sciences are actively involved in research and experimental activities in the field of out-of-school education in Ukraine. One of the most effective organisational forms of research work with gifted youth to create an educational environment is the interdisciplinary laboratory complex MANLab [13]. Here, students have the opportunity to feel part of a real scientific laboratory, participate in professional research and develop themselves as young scientists inspired by creative ideas.

The practical steps taken by the Ukrainian government to support the development of STEM education are reflected in the opening of the Skills of the Future hub in Cherkasy at the STEM Education and Training Centre of the Cherkasy Regional Institute of Postgraduate Education for Teachers. The educational hub is an example of an innovative approach to learning that meets modern educational requirements and promotes the development of future competencies.

The STEM centre is equipped with modern equipment, including a 3D printer, Lego sets, various drones, and a special construction set for modelling robots capable of performing various tasks. After the full-scale invasion, the Institute and the STEM Centre started working with IDP children who do not have the technical ability to access education, and also support teachers in organising the educational process [14].



Another example of the practical implementation of innovations in STEM education in Ukraine is the lessons in Ukrainian educational institutions where students study artificial intelligence as a tool for solving global problems. Students create graphic designs for readings, analyse grammar, discuss investments, read materials from Forbes, and develop applications. The use of artificial intelligence in education is one of the key innovations that contributes to the modernisation of the educational process in Ukraine. AI is increasingly becoming the basis for intelligent management in educational institutions.

For Ukrainian education in the context of martial law and post-war reconstruction, this aspect will be particularly relevant due to possible migration processes that could lead to the loss of intellectual resources. This raises the question of alternatives and replacement of problematic segments of the education sector. The speed of the recovery of Ukrainian society will depend on how quickly and fully this replacement takes place. Therefore, artificial intelligence will occupy a separate niche with clearly defined organisational and administrative problems in education [15]. The introduction of AI in data engineering will contribute to the development of new tools and technologies that can be used to teach students in modern STEM programmes [16].

Artificial intelligence (AI) and machine learning (ML) have covered almost all aspects of modern technology. In 2023, the powerful impact of these phenomena on test automation can lead to rapid progress: increase the efficiency and accuracy of testing, create intelligent test scenarios, provide predictive defect analysis, optimise testing, which will lead to a reduction in manual labour and accelerated test execution [17]. Public policy should promote the introduction of such technologies to improve the quality of STEM education.

A necessary and important element of STEM education is a variety of mass events to engage students, including competitions, tournaments, and hackathons. Examples of such events include the ORT STEM CUP International Project Competition among secondary schools that are part of the World ORT network, held annually since 2016, the SuperUrok All-Ukrainian Competition, held since 2018, the FIRST LEGO League robotics tournament of the City Shaper - Shape the City in You season at the Flight Academy of the National Aviation University (08.02.2020), the hackathon "Team.Hack" of the Youth Design Bureau "Geek Workspace" at the National Centre "MANU" (21-23 March 2014, Kyiv) [1]. Holding such events is a key aspect of the state policy in the development of STEM education in Ukraine.

The most systematic approach in Ukrainian STEM education is the experimental implementation of innovative models and areas in general

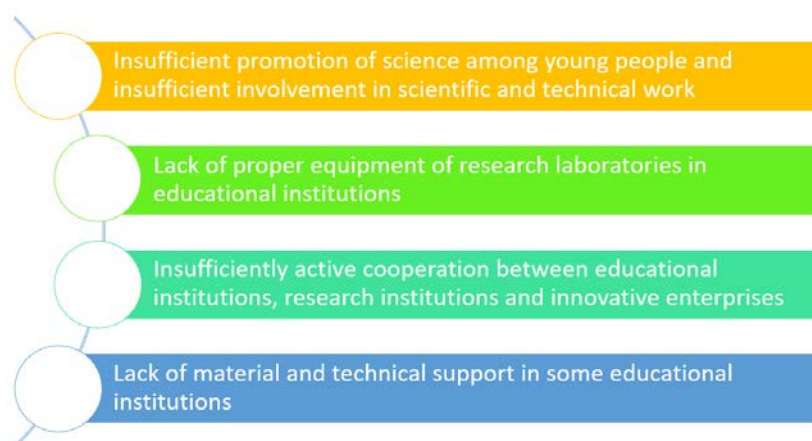


secondary and out-of-school education institutions under the guidance of scientific institutions.

Despite the fact that Ukraine has taken a number of significant steps to develop the education of the future, to form a young generation capable of creativity and critical thinking, and to lay the foundations for the development of STEM education, there are certain difficulties in this process. One of the main obstacles to the introduction of STEM education in Ukrainian educational institutions is inadequate teacher training and the lack of STEM laboratories. Other significant obstacles to the active implementation of STEM education in Ukraine are as follows (Fig. 1):

Figure 1

Main obstacles to the implementation of STEM education



Source: developed by the author based on the analysis of the source [1].

In order to achieve even greater success in innovation, it is necessary to continue to work on removing existing barriers and expanding opportunities for all participants in the educational process. As teachers play a key role in the development of the STEM education ecosystem, they need to be trained in areas such as interdisciplinary approaches in the educational process, the use of digital tools to support STEM education, and the application of innovative pedagogical technologies. It is also important to engage businesses to actively participate and help create educational interschool STEM centres that support an integrated STEM approach to teaching and learning [5].

Conclusions. Today STEM education has significant scientific potential, which requires the creation of STEM laboratories or STEM centres where research and development activities can be implemented. In Ukraine, STEM education is supported and implemented through various types of education, including formal and non-formal education based on STEM centres and laboratories, competitions, festivals, and hackathons.



Implementation of initiatives at the state level will help Ukraine create a strong human resource potential in the technology sectors. This will contribute to innovative development, economic growth and strengthening the country's defence capabilities. It is important to understand that investments in STEM education are investments in the future of Ukraine. We see prospects for further research in the analysis of international experience and its adaptation to Ukrainian realities.

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