

IMPLEMENTATION OF STEM EDUCATION SYSTEM IN UKRAINE

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Summary

The article deals with the contemporary situation in education sphere in Ukraine, describing the main aspects of STEM implementation. The article analyzes the main aspects of a learning strategy STEM which provides students mainly with an interdisciplinary approach to learning. Both the advantageous and disadvantageous issues of this learning approach are revealed in the article. The peculiarities of STEAM learning method in Ukraine have also been emphasized. In the course of the study, it has been discovered that modern educational system faces lots of challenges and needs to be improved by implementing an interdisciplinary approach to learning such as STEM education that promote not only skills such as critical thinking, problem solving, higher-order thinking, but also behavioral competencies such as adaptability, cooperation, organization, and responsibility. Examples of the implementation of STEM-education in the scientific and pedagogical project "Scientific and methodological foundations for creating an innovative model of STEM education" are presented. Despite the fact that Ukrainian schools are just beginning to prepare for work on the principles of STEM, some typical features of the introduction of STEM education, which is new to us, are already obvious. Significant shortcomings are, among other reasons, an insufficient number of teachers willing to work in a new way, and an insufficient material and technical base. These two aspects partially hinder the introduction of STEM-direction, based on the integration of knowledge, attraction of resources, cooperation of skills.

Keywords: Science, Technology, Engineering and Mathematics, Ukraine, STEM teaching experience.

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1. Introduction

The approval by the Cabinet of Ministers of Ukraine of the "Concept for the Development of Science and Mathematics Education (STEM Education)" (2020) confirms the importance of STEM education for Ukraine and at the same time raises the problem of new requirements for the quality training of STEM personnel, which should form in the future own scientific and technical elite of the country. This is possible to implement this training development through the implementation of innovative teaching methods and educational programs aimed at developing cognitive skills, information processing skills, data interpretation and analysis, engineering thinking, research skills, algorithmic and critical thinking, digital literacy, creative qualities and technical skills, as well as improving the training of teachers in STEM subjects and encouraging applicants for education to choose scientific and technical activities.

Analysis of current scientific research and publications. Nowadays much attention is paid to cognitive competencies of the pupil within a new global educational trend. They include both general and special competencies. The theory of STEM-education is highlighted in the works of foreign teachers and psychologists such as M. Harrison, D. Langdon, B. Means, E. Peters, Burton, N. Morel, J. Confrey, A. House. Much is reflected in the works of domestic scientists (V. Andriyevska, S. Babiychuk, L. Bilousova, O. Kuzmenko, N. Morze, T. Nanayeva, N. Omelchenko, O. Patrikeyeva, V. Pikalova, S. Podlesnyi, I. Slipuchina, O. Stryzak, O. Tarasov, I. Chernetskyi, O. Holovina, E. Skibae and others). Most scientists note that STEM education involves an integrated and project approach as well as practical orientation of the method. This topic of present research is at the intersection of various areas such as pedagogy, psychology and philosophy and tackles many aspects of critical and logical thinking study.

The purpose of the article is to explore the peculiarities of educational practices for the development and implementation of STEM education in Ukraine. To this aim we have to find out 1) the ways of the implementation of STEM principles in the educational process; 2) the main aspects of STEM education in Ukraine.

2. Formulation of the main material

In the 1990s, the STEM approach to learning was born in the United States, which is now being implemented at the state level in countries focused on growing their own scientific and technical elite. STEM education is a series or sequence of courses or programs of study mainly for students or post-secondary education students for successful employment. STEM requires different and more technically complex skills, including the application of mathematical knowledge and scientific concepts.

The acronym STEM (S – science, T – technology – E-engineering – M-mathematics) is used to refer to the popular direction in education, including the natural sciences (Science), technology (Technology), technical creativity (Engineering) and mathematics (Mathematics). This is a direction in education, in which the natural science component + innovative technologies is strengthened in the curricula. Technologies are used even in the study of creative, artistic disciplines. (*STEM-osvita, 2018*). Sometimes the letter R is added to this set, indicating Robotics, or the letter A, corresponding to the word Art.

3. STEM principles implementation in the educational process

The STEM approach is based on 4 principles: 1) a project form of educational process organization. Schoolchildren and students are united in groups to jointly solve educational problems. Teachers enhance their students by encouraging them to ask questions, creating an atmosphere of interest and introspection, creating a hands-on experience through projects and activities for the students that is a key aspect of facilitating retention, conducting experiments which are an excellent way to combine STEM factors like collaboration and kinesthetic learning and getting the children's feedback. Along with asking questions, it's also important to request feedback and garner any inquiries from students throughout and after the learning process as well; 2) the interdisciplinary nature of training. Training tasks are designed in such a way that for their solution it is necessary to use the knowledge of several academic disciplines at once; the main focus is put on the coverage of disciplines that are key for the training of engineers or

specialists in applied scientific research: subjects of the natural science cycle (physics, chemistry, biology), modern technologies and engineering disciplines; 3) gender equality promotion. There is currently a wide gap of the number of females working in STEM-related fields. This style of learning provides equal opportunities and encouragement for both genders. There are many different careers that female students can choose to pursue; 4) preparation for college and the workforce. The practical nature of educational tasks, the result of the solution of which can be used for the needs of the family, class, school, university, enterprise, city. STEM education focuses on helping students develop critical thinking and innovation skills, needed to succeed after high school. STEM programs are typically very hands-on and intellectually challenging, and they allow students to develop independence from a young age. While it is important to promote STEM education for students, it is also crucial to begin the STEM journey at a much younger age. Some of the primary reasons for STEM education to be implemented from the earliest days of childhood are as follows: 1) Hands-On Experience. Using kinesthetic learning can develop a pupil's knowledge of subjects like mathematics in an experiential manner for example creating projects of different kinds, rather than strictly in written form. This can provide valuable experience that combines creativity with logical thinking; 2) Memory Retention. STEM education in early childhood allows children to begin to learn and retain a knowledge base that they can build on as they get older; 3) Gamification. It has become an increasingly popular form of motivation and productivity. By exploring important subjects like science and engineering through the playing a game, children can learn to apply gamification to professional and educational pursuits in a profitable manner. Learning through games can be incorporated by both at school and at home; 4) Collaborative Learning. STEM activities encourage students to work together as they innovate and think critically. (Stebbins, M., Goris, T. 2019).

All these basic skills laid in so early age would help to work out the profound basics for the further preparation to successful learning and career.

Critical thinking formation is one of the most important tasks of modern education, as the ability to process information is an integral part of the individual in the information society. The issue of the need to study of the critical and logical thinking formation in schoolchildren and students is studied in the works of prominent scientists, such as O. Holovina and others. As she points out "considering various aspects of critical thinking, we can determine that critical thinking is, in a broad sense, the ability to perceive and analyze messages, or the psychological mechanism of media literacy which is another important component of thinking in today's information society" (Holovina, 2022: 27-28).

4. Main aspects of STEM education in Ukraine

In Ukrainian education, one of the first impetuses for the development of STEM was the order of the Ministry of Education and Sciences of Ukraine No. 188 dated February 29, 2016 "On the formation of a working group for the implementation of STEM education in Ukraine". In 2018, the Dnipropetrovsk region joined the experimental work on the topic "Scientific and methodological foundations for creating an innovative model of STEM education." The purpose of the experiment was to test the effectiveness of the innovative model of STEM education. The experiment was carried out on the basis of 31 educational institutions of the city and region. Institutions of various types participated in the experimental work: specialized lyceums of the natural and mathematical direction, schools in cities and villages, out-of-school educational institutions specializing in the scientific and technical creativity of children and youth (Nakaz departamenty osvity i nauky, 2018).

STEM approaches are beginning to be implemented in some other Ukrainian schools. According to a survey conducted in 2021 by the Institute for the Modernization of Educational Content, more than 150 STEM centers and laboratories operated in Ukraine in the 2020/21 academic year. The introduction of the natural-mathematical approach will continue according to plan until 2027. The program provided for by 2021 to train 100 thousand teachers for STEM schools and allocate budgets for the development of such educational institutions. The goal of the program is to prepare about a million qualified specialists in technical areas.

To develop STEM education, each school can start with the following steps:

- First of all, it is necessary to develop the teaching strategy, taking into account all the recommendations for the disciplines included in the STEM cycle; analyze what equipment the institution has. The required equipment is indicated in the typical list of teaching aids and equipment for classrooms and STEM laboratories;
- if the school has an interesting idea related to STEM, you can try to raise the funds necessary for its implementation on crowdfunding platforms, ask for the assistance of IT companies, tell the world about your idea thanks to local authorities. Besides, it is obligatory to participate in student competitions and Olympiads;
- the introduction of STEM in an educational institution requires the training of scientific and pedagogical workers. In particular, teachers can be trained on the basis of the Institute for the Modernization of Education, which since 2017 has held 9 sessions for more than 21 thousand teachers;
- use distance learning opportunities. For example, to form modern competencies in schoolchildren, you can visit the virtual STEM center of the Minor Academy of Sciences of Ukraine.

According to the action plan, during 2021-2022 it is planned to develop training materials and methodological recommendations for teachers to prepare applicants for education to participate in the PISA international educational study. During this period, it is also planned to update the standards of higher education in the field of knowledge "Education / Pedagogy" on the use of the latest pedagogical approaches to teaching and assessment, the practice of interdisciplinary teaching, methods and teaching aids that contribute to the development of research and inventive competencies.

By 2023 it is planned to develop:

- a series of video lectures for teachers of physics, mathematics and primary school STEM education;
- new content of STEM-education for students of general secondary education (state standards, standard educational and training programs of subjects and integrated courses, elective courses) and extracurricular education (curricula of clubs, sections and other creative associations).

During 2021-2025 it is planned to carry out research and preparation of recommendations using STEM-education methods in educational institutions.

So far, STEM centers are located mainly in large cities. STEM labs in rural schools are a rarity. However, this does not mean that it is impossible to develop STEM education in schools remote from megacities. For 5 years, the Tsarichansky Lyceum (Dnipropetrovsk region) has been implementing STEM education. During this time, new equipment appeared in the institution, students became winners of national invention competitions, and graduates began to choose specialties in natural industries more often. Grants and cooperation with the leaders of the district, which considers STEM education the most promising, helped to achieve success (*Sovremennaya shkola*, 2022).

The Tsarichansky Lyceum began to implement the regional experimental project "Scientific and methodological foundations for creating an innovative model of STEM education" in 2017, and in 2020 it already had some success. For example, among schoolchildren there are three diploma winners of the regional competition of STEM projects – "Industry inspires" and the winner of the same competition in the nomination "Best STEM decoration". Nine-grader Danila Grigoriev managed to get into the international *IPRC ONLINE 2020. Robotcreation contest* and won 3rd place (*Sovremennaya shkola, 2022*).

But in Ukraine, STEM education is connected, first of all, with the system of additional and extracurricular education, which is developing quite dynamically today. Out-of-school STEM education in the state includes various olympiads, the activities of the Minor Academy of Sciences, other out-of-school institutions, and competitions and events: Intel Techno Ukraine; Intel Eco Ukraine; Sikorsky Challenge Science Festival and more (*STEM-osvita, 2015*).

As an example of such a center, we can name the communal out-of-school educational institution "Dnepropetrovsk Regional Center for Scientific and Technical Creativity and Information Technologies of Student Youth", in which a STEM education project has been gradually implemented since 2018. It all started with a regional robotics pilot project, which resulted in the opening of the *DniproBots* robotics school and the new *Interesting Mathematics* club.

The Center initiates various competitions for children of different ages. For example, on February 18, 2021, a regional competition for primary school students in primary technical modeling started. The competition consisted of four tasks in the areas of STEM education: making a 3D model using the *PaperCraft* technique, theoretical credit, making the simplest model of an aircraft from a drawing and a general view drawing, and participating in mini-competitions for flight range.

In addition, the Dnipropetrovsk Regional Center for Scientific and Technical Creativity actively shares its experience and organizes workshops for primary school teachers of experimental institutions involved in the regional experimental work on the topic "Scientific and methodological foundations for creating an innovative model of STEM education".

The innovative STEM school INVENTOR is widely known in Ukraine. It develops in children the ability to solve specific problems in the classroom. Natural sciences, technology, engineering, mathematics are combined in one lesson for children from 3 years old. Students explore the problem, look for solutions, design, program, carry out calculations and experiments, draw conclusions and present the results. The first school opened in 2008, and by the beginning of 2020, 30 INVENTOR branches had been opened in 17 cities of Ukraine, employing 260 teachers and teaching more than 15,000 children. (*Pryntsypp navchannya y STEM-shkoly Inventor, 2022*). There is a similar center in Chernivtsi. In 2021, "Chernivtsi EDU Fest" took place in Bukovina. Its goal was to unite talented young people who are interested in information technology and strive to change the world for the better. The event was held for school students, students of technical specialties and teachers. The festival included master classes, an exhibition of robots and a marathon of engineering projects. In addition, a discussion was held "Digitalization of Education – STEM Challenges and Opportunities for Bukovina". The event was held by the Boteon robotics training center, Noosphere engineering school and Umniki Holding LLC (*Vprovadzhennya STEM-osvity, 2021*).

But is it possible to say that Ukraine adopted the experience of developed countries and was able to implement STEAM technologies in its institutions? Everything seems to be there, everything works. But is this the STEAM we wanted? Are the children, parents, teachers, the state ready for innovation?

Determining the obstacles that hindered the work, we can name the following: lack of support from local authorities, internal problems of the institution, lack of information, lack of clear tasks, lack of funding, lack of an adequate material and technical base, insufficient provision of reagents and equipment for the research work of chemistry classrooms, physics, biology; remoteness from the regional center, where scientific and cultural centers, universities are concentrated, lack of time, insufficient interest of students and parents in in-depth study in STEM areas, lack of close-knit creative groups in institutions.

There are certain risks of implementing a STEM program:

1. Increasing prices for equipment.
2. The growth of wages.
3. The rapid development of new technologies, which leads to the rapid aging of IT equipment.

It is also impossible to ignore such a problem as the financing of the educational industry. It's not about wages, it's about the funding required to implement STEAM. For the equipment of one modern STEM laboratory, at least 1.5 million hryvnias are needed. And for the digitalization of physics, chemistry, and biology classrooms, 1.5 million hryvnias per classroom.

5. Conclusions

STEM education is one of the latest ideas in the educational sphere. As with any educational system, there are different attitudes to this system with the proponents and opponents to it. It's obvious that the STEM approach to education has its effect on students, creating a positive atmosphere to studies, encouraging students to collaborative work, providing the equal possibilities to both genders, and so on, but it also causes certain difficulties. These include restructuring the education system – integrating multiple subjects and their practical application – new teaching principles, restructuring school operation – classrooms, logistics – everything must correspond to new STEM technologies, restructuring the work of teachers – they will be required to take a new, holistic approach with the need to understand related subjects.

STEM implementation initiatives in Ukraine are just beginning to receive government support. Studies confirm the importance of such projects for the development of the country's economy. If at least 1% of the population is involved in the STEM profession, Ukraine's GDP will grow by \$50 billion. STEM education in Ukraine should become a priority, because it is its development that will provide an opportunity for future specialists to become in demand in the highly qualified labor market.

Confucius said: "Don't teach children the way you were taught – they were born in different times... If you want to teach children to think differently, you will have to learn to teach differently".

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