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STAGES AND CONDITIONS OF IMPLEMENTATION OF STEM EDUCATION IN UKRAINE

Abstract. Every year, despite our desires and preferences, innovative processes take place in the world, new technologies are created that permeate all spheres of social life. Thus, the last couple of years have been marked by the emergence of 3D printers, the creation of supermarkets of the future, modernization of production through robotic prefabricated systems, testing of robot buses, the development of virtual reality and artificial intelligence and more. Various innovations also affected the education system of Ukraine. Forms, methods, teaching aids, the role of teacher and student, curricula and assessment systems are changing. With the modernization of the educational process, new directions in education appear. Yes, today you can hear about mixed, inverted, mobile, social learning, video scribing, cloud technologies, inverted classroom, storytelling, start-up challenge, etc. Due to the spread of coronavirus infection and the introduction of quarantine, distance education has become relevant. Thus, at the present stage there is a global reform of Ukrainian education, aimed at changing conceptual priorities, finding ways to integrate into the European education system. One of the promising areas is the introduction of STEM-education, which provides for the integration of natural sciences, which focuses on the development of new technologies, mathematical calculations, innovative thinking. In this context, there is a reorientation of the educational process to the development of personality, and such a reorientation involves the improvement of the entire education system, and consequently the teaching methods of individual disciplines, including natural sciences. To do this, it is necessary to calculate the conditions and stages of implementation of STEM-education in the educational process of general secondary education in Ukraine, which in the future should meet the needs of the country for well-trained engineers and specialists in STEM education.

Keywords: STEM, STEAM, STREAM, STEM-education, innovative methods, New Ukrainian school, competency approach, applied learning.

Introduction. STEM-education (S — science — natural sciences, T — technologies, E — engineering, M — mathematics) [1] — innovative direction in the world education system, which is now being actively implemented in the educational space of Ukraine.

The acronym STEM defines the characteristics of didactics, the essence of which is manifested in a combination of interdisciplinary practices focused on approaches to the study of natural sciences and mathematics.

At the same time, STEM actively includes a set of creative, artistic disciplines, united by the general term Art (designation of the appropriate approach — STEM and Arts). Modern areas of STEM and arts are industrial design, architecture, industrial aesthetics and more. Recently, European scientific discussions have emphasized the importance of all disciplines, the use of interdisciplinary approaches STEAM (letter A — All — all) and the combination of science with other disciplines studied at school.

In European scientific discourse, adding the English letter A to the abbreviation STEAM (A — all — all) emphasize the importance of all

disciplines (arts, humanities and social sciences). That is, the emphasis is on strengthening the links and interactions between science, creativity, entrepreneurship and innovation, as well as the study of natural sciences through other disciplines and, conversely, the study of other disciplines through the natural sciences [2; 3].

At one of the STEM exhibitions of the Western Australian Department of Education, among more than 400 participants, the letter A was interpreted as Agricultural Studies and is agricultural research, not art [4].

Analysis of information and scientific sources allows us to distinguish other abbreviations STEM. Thus, according to the type of integration in educational institutions around the world, ecoSTEM (eco — environmental research, projects in which students' knowledge is used to solve problems in real life), E-STEM (E-environmental — learning through environmental education), STEMM additional M — medicine — medicine, M — management — management) [5; 6].

STEM-education is a category that determines the relevant pedagogical process (technology) of formation and development of mental and cognitive and creative qualities of youth, the level of which determines the competitiveness in the modern labour market: the ability and willingness to solve complex problems (problems), critical thinking, creativity, cognitive flexibility, cooperation, management, innovation. STEM-education is based on interdisciplinary approaches in the construction of curricula of different levels, individual didactic elements, to the study of phenomena and processes of the world, solving problem-oriented problems.

The use of the leading principle of STEM-education — integration allows to modernize the methodological principles, content, volume of educational material of natural sciences and mathematics, technological of the learning process and the formation of educational competencies of a qualitatively new level. It also contributes to better preparation of young people for successful employment and further education, which requires different and more technically complex skills, in particular with the application of mathematical knowledge and scientific concepts.

The main purpose of STEM-education is to implement state policy taking into account the new requirements of the Law of Ukraine “On

Education” [7] to strengthen the development of scientific and technical direction in educational and methodological activities at all educational levels; creating a scientific and methodological base to increase the creative potential of youth and professional competence of scientific and pedagogical workers.

The main key principles mentioned in the New Ukrainian School concept are: communication in state and foreign languages, mathematical literacy, competences in science and technology, information and digital literacy, lifelong learning, social and civic competences, entrepreneurship, culture and etc. environmental literacy and healthy living, harmoniously included in the system of STEM-education, creating a basis for successful self-realization of the individual as a specialist and as a citizen [8].

The purpose of the article. The purpose of research work of scientists of the National Academy of Pedagogical Sciences — to analyse the main conditions for the introduction of STEM in the educational process of schools in Ukraine and its impact on the formation of key and subject competencies in students. The study is based on a pedagogical experiment that lasted for two years (2018–2020) [9].

Analysis of studies and publications. Over the past five years, Ukrainian scientists have conducted a number of studies that define the conceptual and categorical apparatus and the essence of the basic concepts of STEM education [10]. Formation of educational STEM-environment (V. Bykov) [11]. Formation of key and subject competencies of students by robotic means of STEM-education (N. Morse) [12]. Methodical recommendations for the development of STEM-education in general secondary and out-of-school education institutions have been developed (I. Vasylyashko, O. Patrikeeva, O. Lozova, N. Burkina) [13]; methodical recommendations on introduction of STEM-education in the conditions of integration of formal and non-formal education of gifted students (N. Polikhun, K. Postova, I. Slipukhina, G. Onopchenko, O. Onopchenko) [14]. STEM as a modern polytechnic education is considered by V. Sippii [15]. T. Zasekina and T. Nazarenko are engaged in the integration of natural sciences on the basis of STEM-education through the introduction of the course “Natural Sciences”.

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of Ukraine working on the content of “Concepts of teaching geography of Ukraine in primary and secondary school” and “Concepts of economic education in gymnasiums and lyceums of Ukraine” took into account STEM education trends [16; 17].

As we can see, there is a sufficient scientific and practical-methodical base for the development and implementation of STEM education in educational institutions.

Presentation of the basic research material and substantiation of the obtained scientific results.

The introduction of STEM-training on the basis of personality-oriented, activity-based and competence-based approaches should take place within the current legislation without the expectation of a full transition to the second generation of the State Standard of basic and complete general secondary education and new curricula. It is expedient to do this in order to understand the directions of educational reforms and, at the same time, to make the teaching of students better and more modern today. These approaches should be introduced gradually in both primary and specialized schools.

In their work, teachers use a glossary of terms, which was created by State Scientific Institution “Institute for Modernization of Education” in order to promote and harmonize understanding of the concept of STEM, scientific and methodological approaches to the development of STEM-education [18].

A special form of end-to-end STEM-learning is integrated lessons / classes, which are aimed at establishing interdisciplinary links that contribute to the formation of students’ holistic, systematic worldview, the actualization of personal attitudes to the issues addressed in the lesson.

Integrated lessons can be conducted in two ways:

- by combining similar subjects of several subjects;
- through the formation of integrated courses or separate special courses by combining the curricula of such courses / subjects.

In order to involve students in practical activities, it is desirable to expand the range of organizational forms, teaching methods, methods of educational interaction and give priority to learning material in the process of excursions, quests, competitions, festivals, hackathons, workshops and more.

During the implementation of educational projects, a number of different levels of didactic,

educational and developmental tasks are solved: new knowledge, skills and abilities that will be needed in life are acquired; develop motivation, cognitive skills; the ability to independently navigate in the information space, to express their own judgments, to show competence is formed. Design and research activities contribute to the formation of social competencies, allows you to go through a technological algorithm from the emergence of an innovative idea to create a commercial product — a start-up, as well as learn to present it to potential investors. In the long run, this contributes to the change of value priorities and worldview of young people towards the formation of responsible, socially active, socially and patriotic balanced behaviour.

Conditionally in the implementation of STEM-education, considering this category as an innovative technology, we can distinguish the following stages:

- organizational and preparatory, exploratory: study of the state of implementation of STEM-education in Ukraine and the development of this problem in the scientific and methodological literature; selection of scientific and practical materials, electronic resources, formation of regulatory framework, etc;
- conceptual-diagnostic: definition and substantiation of the basic terms of STEM-education; creation of a glossary of terms that define the essence of the concept of STEM-education; development and approval of legal documents (Concepts of STEM-education, Standard regulations on STEM-center, Standard regulations on equipping teaching aids and equipment of classrooms and STEM-laboratories, etc.);
- formative: approbation of the best world methods and technologies of STEM-education in educational institutions in order to check their effectiveness;
- analytical-generalizing: generalization of results of approbations and introduction of STEM-education methods in the educational space of Ukraine, definition of advantages and disadvantages, preparation of reports.

In August 2015, the STEM-education department of DNU “Institute for Modernization of the Content of Education” was established, which has a number of tasks. The implementation of STEM-education ideas is carried out by involving students in various contests, competitions,

tournaments. Thus, scientific picnics, robotics festivals, all-Ukrainian competitions “Robot traffic”, competitions on modeling of “smart” devices “STEAM-House”, programs-competitions “FIRST LEGO-league”, “FIRST LEGO-league-junior”, are actively held in Ukraine etc.

The action plan for the implementation of STEM-education in Ukraine for 2022 provides for the establishment of STEM-centers / laboratories on the basis of secondary schools (regional support schools), out-of-school educational institutions, research laboratories with appropriate material, technical, scientific and methodological base, specialists for the organization of effective educational and research and project activities. The work of STEM centers / laboratories should be regulated by the current Regulations and be aimed at supporting and developing STEM education.

The effectiveness of STEM-training, the introduction of innovative methods of the New Ukrainian School, depends on updating the material and technical base of both the subjects of the natural-mathematical cycle and the educational institution as a whole. Educational, modern information tools, measuring systems contribute to the motivation of research, intellectual and creative activities of students, the development of cognitive interest and the formation of subject competencies, while creating appropriate conditions for the development of specialized training.

The process of implementation of educational STEM-projects involves active interaction with parents and communities.

Observing the events taking place in the world and in Ukraine related to the pandemic and quarantine due to the 2019 coronavirus, we consider the creation of the Virtual STEM-Center (Virtual STEM-centre MANLab) in 2020 to be quite relevant. Today the Virtual STEM-centre of the Small Academy of Sciences of Ukraine — STEM-laboratory MANLab offers distance and day professional methodical and technological assistance in the organization of STEM-training of student youth of Ukraine.

Conclusions

Studying the experience of different countries in the implementation of STEM-education, we note that there is no single clear understanding of this term and its definition is given very differently. However, everyone agrees that this technology, paradigm, system, methodology, as it is called,

teaches to live in real life, think critically, apply the latest advances in science and technology, form the skills of the XXI century and much more.

Favourable conditions for the introduction of STEM education have been created in Ukraine. Today we see only the introduction of elements of this innovative direction. There is a need to create training programs in the areas of STEM and their approval at the state level, building a network of STEM-centres.

The popularization of STEM areas is also carried out through publishing activity and participation in various activities of scientists, teachers-practitioners, methodologists, graduate students, doctoral students.

Analysis of the latest scientific and methodological publications, research shows that STEM has attracted the attention of the Ukrainian public. A significant number of conferences, seminars, round tables, webinars at the national and international level testify to the relevance of the introduction of STEM education. Participants in the educational process share experiences, advanced ideas, the use of STEM-technologies on the pages of thematic groups in social networks.

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ЕТАПИ ТА УМОВИ ВПРОВАДЖЕННЯ STEM-ОСВІТИ В УКРАЇНІ

Анотація. Щороку, незважаючи на наші бажання та вподобання, у світі відбуваються інноваційні процеси, створюються нові технології, які пронизують усі сфери суспільного життя. Так, останні роки ознаменувалися появою 3D-принтерів, створенням супермаркетів майбутнього, модернізацією виробництва за допомогою роботизованих збірних систем, тестуванням роботизованих автобусів, розвитком віртуальної реальності та штучного інтелекту тощо. Різні нововведення торкнулися й системи освіти України. Змінюються форми, методи, засоби навчання, роль вчителя й учня, навчальні програми та системи оцінювання. З модернізацією навчально-виховного процесу з'являються нові напрями в освіті. Так, нині можна почути про змішане, перевернуте, мобільне, соціальне навчання, відеоскрайбінг, хмарні технології, перевернутий клас, сторітелінг, стартап-челендж тощо. Через поширення коронавірусної інфекції та введення карантину стала актуальною дистанційна освіта. Отже, на сучасному етапі відбувається глобальна реформа української освіти, спрямована на зміну концептуальних пріоритетів, пошук шляхів інтеграції в європейську систему освіти. Одним із перспективних напрямів є впровадження STEM-освіти, яка передбачає інтеграцію природничих наук і орієнтується на розвиток нових технологій, математичні розрахунки, інноваційне мислення. У цьому контексті відбувається переорієнтація навчального процесу на розвиток особистості, причому така переорієнтація передбачає вдосконалення всієї системи освіти, а отже, і методики викладання деяких дисциплін, зокрема природничих. Для цього необхідно розрахувати умови й етапи впровадження STEM-освіти в навчально-виховний процес загальної середньої освіти України, яка в перспективі має задовольняти потреби країни у добре підготовлених інженерах та спеціалістах зі STEM-освіти.

Ключові слова: STEM, STEAM, STREAM, STEM-освіта, інноваційні методи, Нова українська школа, компетентнісний підхід, прикладне навчання.

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ЭТАПЫ И УСЛОВИЯ ВНЕДРЕНИЯ STEM-ОБРАЗОВАНИЯ В УКРАИНЕ

Анотація. Каждый год, несмотря на наши желания и пристрастия, в мире происходят инновационные процессы, создаются новые технологии, пронизывающие все сферы общественной жизни. Так, последние годы ознаменовались появлением 3D-принтеров, созданием супермаркетов будущего, модернизацией производства с помощью роботизированных сборных систем, тестированием роботизированных автобусов, развитием виртуальной реальности и искусственного интеллекта. Разные нововведения

затронули и систему образования Украины. Изменяются формы, методы, способы обучения, роль учителя и ученика, обучающие программы и системы оценки. С модернизацией учебного процесса возникают новейшие направления в образовании. Так, сегодня можно услышать о смешанном, перевернутом, мобильном, социальном обучении, видеоскрайбинге, облачных технологиях, перевернутом классе, сторителлинге, стартап-челленджах и т. д. Из-за распространения коронавирусной инфекции и введения карантина стало актуальным дистанционное образование. Таким образом, на современном этапе проходит глобальная реформа украинского образования, направленная на изменение концептуальных приоритетов, поиск путей интеграции в европейскую систему образования. Одним из перспективных направлений является внедрение STEM-образования, которое подразумевает интеграцию естественных наук и ориентируется на развитие новых технологий, математические расчеты, инновационное мышление. В этом контексте происходит переориентация учебного процесса на развитие личности, причем такая переориентация предполагает усовершенствование всей системы образования, а следовательно, и методики преподавания отдельных дисциплин, в том числе естественных. Для этого необходимо рассчитать условия и этапы внедрения STEM-образования в учебно-воспитательный процесс общего среднего образования Украины, которое в перспективе должно удовлетворять потребности страны в хорошо подготовленных инженерах и специалистах STEM-образования.

Ключевые слова: STEM, STEAM, STREAM, STEM-образование, инновационные методы, Новая украинская школа, компетентностный подход, прикладное обучение.

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