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DESIGN OF THE EDUCATIONAL ENVIRONMENT FOR STEM-ORIENTED LEARNING

Abstract. The article examines the impact of market requirements on the educational system, technological development of society and changes in the economic development of the country. The main directions of changes in European educational policy and their formalization in the framework of competences have been reviewed. The considered practices of organizing educational space in Ukraine and other countries allowed determining the structure of the interaction of participants in the educational environment of STEM-oriented training: administrative and managerial component, cooperation between education and business structures, scientific and methodological support, technological factor, popularization and human factor. The article gives a definition of the educational environment of STEM-oriented learning. According to each of the points of this structure, the peculiarities of their implementation in Ukraine have been presented: steps to implementation at legislative level have been taken, a list of measures aimed at popularizing and supporting STEM-education has been developed, a way of the dissemination of these ideas has been outlined and the list of already existing developments and implementation practices has been made. The conditions required for the development of educational STEM-environment have been defined. The article presents the model of the educational environment of STEM-oriented learning developed at the STEM-school of Kherson State University. The description of the project activity of the teacher and students in the context of the creation of educational environment of STEM-oriented learning is given. Also, the article offers examples of interdisciplinary projects. Their implementation requires that the teacher have a good theoretical foundation in mathematics, physics, technology and programming.

Keywords: STEM-education; educational environment of STEM-oriented learning; teacher's activity; interaction; popularization of STEM; interaction structure; model of operation.

1. INTRODUCTION

Problem statement. The Fourth Industrial Revolution changes the existing business models and, accordingly, has a significant impact on the labor market. Digital technologies penetrate each sphere of human activities and change the requirements to employees. These changes imply the need for the qualified staff competent in digital technology. Graduates of higher education institutions, having completed their studies, are supposed to have the appropriate competences meeting the demands of the labor market. At the same time, we have

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a number of contradictions between the skills that young people receive during their studies and those that are actually in demand on the labor market. There are many factors behind such situation: the lack of students' involvement in the project activity, the use of information technologies as support for traditional teaching methods, rather than as main educational tools, teacher's unwillingness to introduce digital technologies into the educational process, and the need for technical support. Another reason for the shortage of skilled personnel is that a rather small number of people choose engineering and technological careers: students consider these professions difficult to master or boring.

To solve the problem of involving students in engineering and technological creativity and to increase supply of qualified personnel to the market, it is necessary to have guidelines that will contribute to the establishment of criteria for the formation of a specialist trained in technology. The problem of hiring qualified personnel is common to all countries. Digital competences help solve this problem. They were identified as one of the key areas for lifelong learning in 2006. The European Parliament and the Council of the European Union have adopted "Recommendations on key competencies for lifelong learning", which are: "Knowledge of mathematics and general knowledge in science and technology" and "Skills in working with digital media". Since 2015 there has been a gradual update of the Digital Competency Framework (DigComp 2.1) [1]. This document has become the basis for developing further documents: DigCompEdu Teacher Digital Competency Framework, DigComOrg Digital Competency Framework [2], [3]. They serve as instruments for evaluating digital competencies for various purposes (learning, work).

Ukraine is on the way of introducing digital technologies into all areas of education, which leads to continuous improvement of educational content and the quality of specialists' training. In Ukraine reforms are now aimed at building a powerful state and a competitive economy that "... can provide a cohesive community of creative people, responsible citizens, active and enterprising. The orientation of training towards STEM-technology and raising the scientific and technological potential of the population is a priority task of the state's innovation development "[3]. Today, there are difficulties in transferring technology due to the problem of society's slow adoption of the technological world. But gradually, all innovations are being integrated, uniting specialists around solution of urgent problems, such as fighting diseases or dealing with natural disasters. The natural consequence of these changes is the globalization of all innovation processes. New technologies are now affecting not some specific individual human activities, they are changing all of them. The strategy of professional training of qualified educational staff at educational institutions should take into account the changes and introduce new approaches to attracting young people to engineering and technological careers. To implement successfully STEM-education (Science, Technology, Engineering, Mathematics), it is necessary to determine principles of the formation and functioning of the educational environment, its structure, to study the features of interaction of all participants in this system.

Analysis of recent research and publications. The official beginning of the introduction and development of STEM-education in Ukraine dates back to 2016, when the Ministry of Education and Science of Ukraine created a working group on the introduction of STEM-education. This allowed bringing the society's attention to scientific and technological creativity, STEM-education and its opportunities to develop innovative thinking, to involve young people in the development and implementation of innovations and the spread of positive practices.

Today there is a group of scientists, whose research is related to the terminology and definition of the basic concepts of STEM-education – N.P.Goncharova, N.O.Goncharova, M.L.Rostoka, N.I.Polichon, O.E.Strizhak, I.A.Slipukhina, I.S.Chernetsky [4], [5]. Also, a part of the publications of teachers and lecturers in professional forums and blogs (for example,

the online Vseosvita resource) is concerned with the theoretical and methodological principles of the implementation of STEM-education and the search for effective approaches to the use of innovative technologies in STEM-learning and the construction of models for its development.

O.V.Barna, N.R.Balik have analyzed theoretical and methodological principles of developing the model of STEM-education, its main features, as well as the experience of designing a modern STEM-centre based on higher education institutions. S.L.Gorbenko , O.V.Lozova , O.O.Patrickeyeva , K.G.Postova have highlighted the current state of implementation of STEM-education in Ukraine and various means of STEM-learning in extracurricular education.

Studying foreign experience is necessary to analyze the positive and negative impacts on the development of scientific and technological potential of young people and their involvement in innovative activities. Overseas experience in implementation of STEM-education has been studied by N.V.Valko , T.A.Hannichenko , O.A.Kovalenko , O.V.Saprunova [6]-[8]. The works show successful examples of the implementation of STEM-education in different countries of the world, as well as their impact on the dissemination of STEM-innovations in the educational space of Ukraine.

A.M.Kukh , V.D.Sharko , N.I.Polihun , I.A.Slipukhina , I.S.Chernetsky outllined the policy of introduction of STEM-education and development of scientific and technological competence of youth, the introduction of STEM-education in institutions of pedagogical education, and formulated recommendations for the development of domestic STEM-education [9]-[12].

The list of scientific and practical publications covering the results of theoretical and experimental studies in the field of STEM-education is presented in the works of I.V.Kamenieva, M.V.Kovalenko, O.O.Patrickeyeva, V.V.Chernomorets, O.S.Kuzmenko [13], [14]. They consider different approaches to the development of STEM programs and determine their main characteristics, such as: topical and innovative content; clear implementation process; universal methods, which allow using the program in educational institutions of different levels, types and forms; criteria and tools for determining and measuring the achieved educational and pedagogical result. In addition, they indicate the classification of STEM-programs in terms of directions, forms of training and timing of implementation [13].

Interdisciplinary approach to STEM-education, the organization of integrated study in natural sciences and mathematical cycle and the results of implementing the concept of STEM-education, taking into account the national qualifications framework, are investigated by V.M. Andriyevskaya, L.I. Bilousova, S.M. Babiychuk, V.M. Bahashova, T.V. Isaac, V.V. Osadchy, I.M. Savchenko and others. [15]-[17].

The conducted research has shown that today the problem of introduction of STEM-education in general is gradually attracting more and more attention. But, at the same time, the level of theoretical and methodological elaboration of the problem of introducing STEM-education into the educational process is insufficient. There is a need to specify terminology, concepts and definitions of STEM-education, and to identify factors, tools and methods that allow young people to be effectively involved in scientific and technological activities by choosing STEM-careers. One of these factors is the educational environment of STEM-oriented learning.

Formulation of purpose, statement of tasks. The purpose of the article is to define the term "educational environment of STEM-oriented learning" and to establish the structure of interaction between participants of STEM-learning. To achieve this goal, the following tasks are addressed: the study of approaches to the definition of the "educational environment of STEM-oriented learning", the analysis of the conditions for the development of the STEM-

oriented educational environment, the framework of the interaction of participants in the educational STEM-environment, the presentation of the model of the educational environment of STEM-oriented learning (case study of the STEM-school of Kherson State University).

2. RESEARCH METHODS

Our research involved empirical and theoretical methods. The analysis of key components of the educational environment for STEM-oriented learning and the processes of implementation of STEM-education that are taking place in Ukraine has been carried out, the normative documents, publications and scientific works on the implementation of STEM-education in Ukraine and other countries have been studied and analyzed, as well as direct and indirect observation of the activity of groups and centers of STEM-education in Ukraine has been conducted.

3. THE RESULTS AND DISCUSSION

Presentation of the main research material. In Ukraine, in 2013, the National Strategy for the Development of Education for the period up to 2021 was approved, which states that "... the key task of education in the 21st century is the development of thinking oriented towards the future. The modern labour market requires not only profound theoretical knowledge, but also the ability to independently apply it in non-standard, constantly changing life situations, the transition from a knowledge society to a society of competent citizens" [18].

Implementation of a new educational policy involves the introduction and development of STEM-education in Ukraine, aimed at innovative development in the field of natural sciences and mathematical disciplines and the involvement of young people in research. The basis of the system of changes is the model of the person-oriented learning system. The interaction between a student and a teacher in such a system is based on the principles of cooperation and freedom of choice. Strengthening the role of digital technologies in education creates another level of interaction – an educational environment based on technology, digital representation of information, data and access systems [19]. The educational environment is, on the one hand, a system of means of action, and on the other hand, it acts as a separate subject of activity, since it plays the role of a mediator between a teacher and a student. Structurally the educational environment consists of three interconnected components [9]:

- subject and resource component determines the agents of the educational environment (teachers, students, parents) and the conditions for the implementation of their interaction;
- facilities component is responsible for providing the educational environment with appropriate equipment;
- ideological and technological component defines normative methods and technologies for achieving predicted learning outcomes.

The "Ukrainian Pedagogical Dictionary" by S.U.Goncharenko does not have a definition of "educational environment". However, this term is sufficiently researched by many scholars, for example [9], [19], and others. The definition of the educational STEM-environment is absent in works [5], [20], the work on completing the glossary is still in progress. However, these works offer the following definition: STEM-education is a series or sequence of courses or training programs that prepare students for successful employment,

before or after school, and require different and more technologically challenging skills, including the use of mathematical knowledge and scientific concepts.

Based on these definitions, educational environment of STEM-oriented learning will be understood as a set of objective external conditions and social factors that influence the formation of the scientific and technological outlook of the individual; it is a necessary component for the successful functioning of STEM-education.

As a benchmark for determining the key components of the STEM-based learning environment, let us consider the US experience. Under the direction of the National Science Foundation (NSF), the vision of STEM-education was formed in the country, or «STEM 2026» [21], which noted the importance of:

- developing an educational STEM-environment where everyone is responsible for their experience and professional growth;
- creating an atmosphere of the laboratory (incubator) in the classroom where students, together with teachers, cooperate and at the same time discover science;
- designing a self-regulated, flexible inclusive learning environment with intelligent learning systems to provide an individualized learning approach;
- an organic combination of a school with production and research institutions to enable students to see how professionals use their knowledge in working conditions.

Each of these points characterizes structurally one of the components of the educational environment: agent, resource, facilities or ideological and technological component. But, at the same time, each of them specifies the scientific and technological aspect of such an educational environment. The analysis of the experience of organizing STEM-education in other countries [5]-[8], [22], [23] allowed highlighting the key components of the educational environment of STEM-oriented learning and to determine the structure of the interaction of participants in it (Figure 1):

- Administrative and management component – the organizational effort to implement STEM-education in teaching and management, as well as reorganization of educational space.
- Technological factor – the use of digital technologies as educational tools helps to build an integrated educational environment, which combines science, technology, engineering and business, which in practice can implement innovative ideas, develop prototypes of devices.
- Provision of scientific and methodological support – the development of curricula and elective courses, testing and implementation of new approaches to educational activities. Different stages of implementation of STEM-education require research in the field of definition of content and technology for their implementation.
- Cooperation – the establishment and development of partnerships between education and businesses. It will help keep up with pressing issues, implement innovative ideas and provide hands-on training and access to technology.
- Promotion of STEM-education – motivating young people to solve scientific and technological problems through a system of centers, laboratories, circles, science museums, etc.; through festivals, contests, quests, etc.
- Human resources – educated, better trained and well-educated professionals help strengthen innovation. Continuous education and lifelong learning will help to meet the educational needs of human resources, as well as provide business with well-qualified specialists.

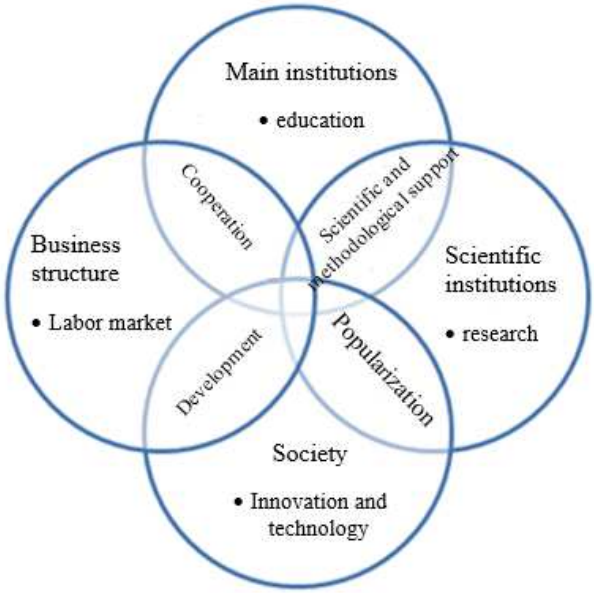

Fig. 1. The structure of the interaction of participants in the educational STEM-environment

Let us consider the peculiarities of realization of each of the points specified in the structure of the interaction of the participants in Ukraine.

Administrative and managerial support is a necessary component of the successful implementation of innovative changes in education. It is necessary to develop and regulate the legal framework for STEM-education. Implementation of the necessary measures of world-oriented trends at various organizational levels of government and education, changes in the laws on education and its levels, the development of a national qualifications framework for all levels of education – these are the steps that are necessary for qualitative changes in education [24]. In order to implement STEM-education, in 2016 a special working group was created at the Institute for Modernization of Educational Content. Its functions include the development of the regulatory legal framework for STEM, the conduction of scientific research, the dissemination of experience and achievements in the field of STEM-education, the study of domestic and foreign experience, the establishment of links between participants in the educational industry. To date, the department has developed methodological recommendations on the implementation of STEM-education. In secondary and extracurricular schools a system aimed at dissemination of the best international and domestic practices through a series of webinars, workshops and educational centers was created. Agreements on implementation of STEM training in cooperation with educational institutions were signed. Memorandum on the creation of the STEM-Education Coalition with leading educational institutions of Ukraine was signed. Such systematic work helps to organize the training of educators in keeping with the new content of education and new management processes at educational institutions, modern electronic content.

Cooperation with business and industry is carried out mainly through the implementation of joint programs in the field of robotics and IT technologies. Joint programs are designed for both schoolchildren and youth. One of the large-scale and successful collaborative projects for students is the Sikorsky Challenge (KPI) business start-up incubator. As a part of this project, young people have the opportunity not only to innovate, but also to transfer their innovations into a business project. There are also a large number of projects in programming and robotics for schoolchildren. The Ministry of Education and Science of Ukraine has signed agreements on cooperation with Innovative Educational

Solutions Company. This company develops and implements methodological and didactic materials for educational institutions. It also develops innovative training curricula and integrates them into a school math course and computer science course. These curricula are based on the use of educational sets of LEGO Education.

An important result of cooperation between education and business was the development of scientific and methodological support and the development of new curricula for the secondary school. To date, separate programs have been introduced in each training centre – Inventor, BOTEON, CodeClub, local art groups, etc. The Ministry of Education and Science has approved the curriculum of the elective school courses in robotics: Technology of the developing of electronic devices (2013, authors: S.M. Dziuba and others.), Technology of control of robotic systems (2013, authors: S.M. Dziuba, et al.), Fundamentals of robotics (2014, authors: T.I. Lysenko, et al.) [25]. Within the framework of cooperation with the "Innovative Educational Solutions" company a curriculum of the elective course "Robotics" was developed (2018, authors A.D. Vasiliuk, et al.). In May 2018, the expert-advisory committee on digital technologies in education at the Ministry of Education and Science of Ukraine was founded. Among its members are leading scientists and business representatives V. Omelchenko, N. Morze, S. Dziuba, companies: Cisco, Networking Academy, Code Club UA, Center BOTEON Robotics, BrainBasket Foundation, etc. This committee will contribute to the introduction of advanced information technology training in the school curriculum in accordance with modern methods, requirements for textbooks and school digital equipment. Under the supervision of this group, classes on the "IT schoolboy" project have been held in three pilot schools (Kyiv and Chernihiv region). It is planned to develop curricula for teaching 3D-modeling, robotics, cyber security, cloud technologies, etc. The developing of such curricula will enable the provision of high-quality modern education in all educational institutions of Ukraine.

The availability of technology is an important factor in the STEM-education development and it significantly affects the education system and requires a change in education policy. The volume of information has grown a thousand times, and it is no longer necessary or physically possible to memorize it – the modern access to information makes it public, thereby giving it rapid propagation and distribution in space. The emergence and development of digital technologies not only has changed the way of processing, storage and transfer of knowledge in accordance with the needs of society, but also has adapted the contributions of past times to the present. In order to see the paintings of famous artists or to read the works of classics in the original we do not need to go to other states, or wait for a long time for photocopies. Artificial intelligence depicts a painting in the style of a famous artist; digitized books are in the public domain, and virtual reality can transfer us to any corner of the world. It has become commonplace that teachers organize lessons to foster online communication of students with their peers in other countries, for example through Skype. Distance learning gives an opportunity to build your educational trajectory as a student and teacher independently.

The popularization of STEM-education brings positive changes to the system of early involvement of young people in scientific, technological and innovation activities. There are various forms of it: festivals, competitions, competitions, quests, etc. Such activities and participation in them are a prerequisite for the promotion of innovation. Young people have the opportunity to present their projects to businesses and receive feedback or suggestions for their development or financing. In Ukraine, there is a large number of events aimed at promoting STEM-education among young people: the Kyiv Mini Make Fair Innovation Festival, IT Festival 4.0 (Flight Academy of the National Aviation University, Kropyvnytsky), the FIRST LEGO League and FLL Jr. festivals, (Innovative Educational Technologies), Rotational Competition (ORT), Robotronica and ROBRICE competitions

(Odesa National Academy of Food Technologies), Youth Technology Festival "Spring soft" (Kropyvnytsky), Tech Fest Festival and BestRoboFest in Dnipro, scientific picnics (in different cities of Ukraine), the Olympiad on robotics AsimovOlympics (Kharkiv-Kyiv-Odessa), the All-Ukrainian Innovation Festival, Ferrexpo Robot Fest (Gorishni Plavni), Sikorsky Challenge (KPI). The camps for children and young people become popular during the vacation period – robotics camps (cities of Kyiv, Mykolaiiv, Kharkiv, Kherson), programming camps (Dnipro, Kyiv, Kremenchug, Kharkiv), summer mathematical schools (cities of Kyiv, Lviv, and Kharkiv).

The quality of STEM-education is determined by the professional level of the teacher, their STEM-competence and ability to involve others in the scientific and technological activities.

That is why the organization of STEM-education is relevant for trainee teachers and will help them become effective and competitive in the labour market in the context of rapid technological change. The introduction of the new state standard of primary general education (2016), as well as changes planned in the standards for secondary and high school, require appropriate professional training of teachers. The public educational policy enables teachers of all specialties to develop and implement new integrated approaches to education, according to the doctrine of educational reform that has been taking place in recent years. Therefore, the creation of curricula for STEM-education should be aimed at pre- and in-service teachers. STEM-education should involve the formation of the skills necessary for the job, develop skills throughout the practice and improve them through advanced training.

The development of an educational environment for STEM-oriented learning involves observing the following basic conditions:

- Interaction at all levels of the educational system – students-teachers, colleges-universities, etc.
- Virtualization of educational space – digital technology is present on a par with other training tools.
- Personality orientation – designing the educational trajectory in accordance with the needs and requirements of the student.
- Modularity – a curriculum is structured so that individual units can be modified and combined with other curricula. This will allow the modification of the functionality of the curricula, enhance their integration and promote timely updating.

The importance of this issue encourages teams of scholars from different universities of Ukraine to open STEM-centres at their educational institutions, for example, at V. Hnatiuk Ternopil National Pedagogical University, B. Grinchenko Kyiv University, Bohdan Khmelnitsky Melitopol State University, Kherson State University.

The two-year experience of the STEM-school at Kherson State University (KSU) shows that interaction at all levels of the educational process among the participants is a key factor for successful learning [26]. The model of the educational environment of the STEM school, shown in Figure 2, demonstrates the interaction among all participants in the educational process. Such a model fully implements the structure of the interaction of all participants in the educational STEM-environment presented above.

It should be noted that mastering basics of robotics, programming, and 3D modeling by students involves three consecutive levels of learning project complexity (basic models, ready-made solutions and open-source projects). The first two levels involve providing ready-made instructions and sample assignments. However, base models, which form the basis of the first level, are used as part of more complex projects of the second and third levels of complexity.

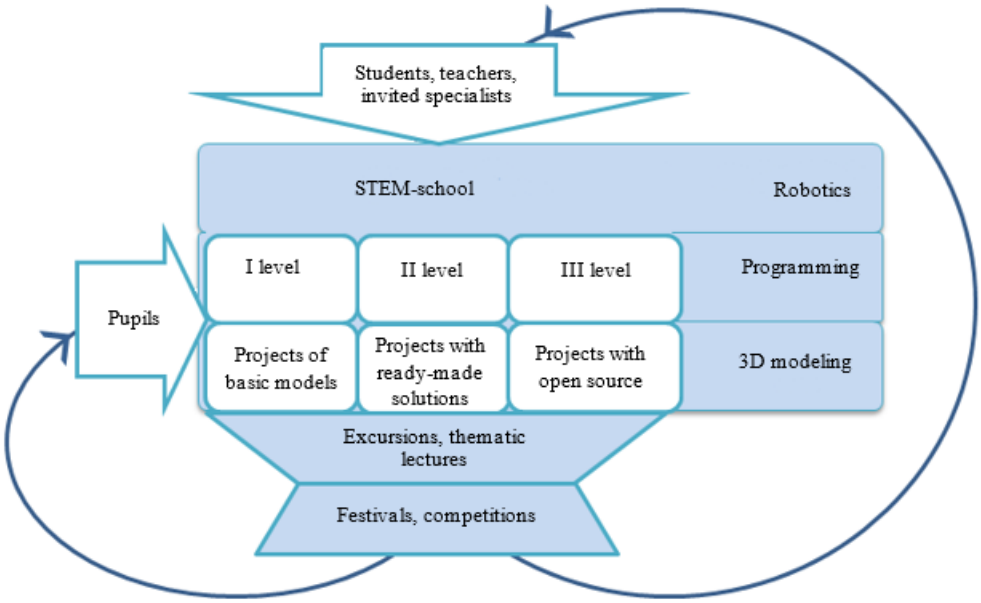

Fig.2 Model of the STEM-school educational environment

On the basis of STEM-school there are classes for school-age children in the basics of programming and robotics. The rationale for this choice was made earlier [27], [28]. It should be noted that the choice of educational subjects is not limited to the indicated ones. For example, the International Green School [29] is organizing STEM-based learning programs based on building codes.

Studying robotics on the one hand requires the availability of certain technological facilities, and on the other hand, a good knowledge of physics, programming and mathematics. In addition, each robotics project is a solution to a complex problem of social, economic, or environmental relevance. Table 1 provides some examples of environmental conservation and restoration projects that are carried out within integrated activities.

Table 1.

Examples of projects

Projects	Discipline
– The problem of waste – Green power – Petroleum products, purification of reservoirs – (smart greenhouse, house, meteorological station, etc.)	– Natural science – information on species, quantity, recycling of garbage, classification – Physics – energy, its types, mechanics and electronics (according to the topics). – Chemistry – inorganic chemistry, solutions, compounds. – Mathematics – to establish a connection between input and output data, the construction of mathematical models. – Informatics – processing of numerical data. – Technologies – utilizing and recycling of garbage, production of handmade paper (other products). Manufacturing of power-saving devices and cleaning devices. – Economy – cost of devices, project budget. – Social and healthcare sector – presentation of a project to the general public at exhibitions and festivals, representation at foreign events, communication in the professional environment.

Each of these projects can be scaled according to the levels of student learning. Levels of education are the stages of STEM-education. Here are the characteristics of each of these steps (Table 2).

Table 2.

Characteristics of students' project activity

	Stage I - technological literacy	Stage II - deepening of knowledge	Stage III - creation of knowledge
Models	Work with basic models, concepts	Work on projects with a ready-made solution	Work on open source projects and personal projects
Characteristics of the project	Projects with one solution. A simple constructive problem that reflects a need or desire that includes certain criteria for success and constraints on materials, time or value	Projects with several options. Creation and comparison of various possible solutions based on the problem	Projects with many options. Analysis of test data to determine the similarity and differences between several technical solutions to determine the best characteristics of each one that can be combined into a new solution to meet the criteria for success
Teacher's actions	The teacher knows the result, the ways of achieving it, the mistakes that may arise	The teacher knows the result, the ways of achieving it, the mistakes that may arise	The teacher knows what the result is, but there has not been a finished solution yet, possible errors and ways to achieve the result have not been identified yet
Student actions	Students create prototypes based on patterns, based on examples of their life experiences	Students create their designs, taking into account the requirements of the project, looking for templates	Students must constantly work with the criteria, comparing them with the results, modify the decision, build templates

In addition to classes with children on the basis of STEM-school, other types of work are carried out, which implement the presented structure of interaction of all participants in the educational STEM-space:

- classes and excursions for students,
- training seminars for teachers,
- teaching internship for trainee teachers,
- involvement of young people in R&D through organization and participation in competitions and festivals,
- lectures delivered by leading specialists and successful people.

The tasks of STEM-school are:

- Support of scientific, technological and engineering components in informal education of students.
- Making natural science and engineering laboratories available to students and teachers, providing access to advanced equipment and innovative programs.

– Motivation of senior students for continuing education in scientific, technological and engineering spheres.
– Popularization of inventive and research activities.
– Project-oriented study of students under the guidance of young scientists and engineers.
– Increase in the number of schoolchildren, future entrants who are interested in technology, programming, research in related industries.
– Formation of the expert community in the field of STEM-education, including further education of teachers and instructors, in particular in the area of robotics.

Today, STEM-school is working on creating conditions for adaptation and implementation of innovative programs created by Master students, PhD students, academics of Kherson State University, leading IT companies and enterprises.

4. CONCLUSIONS AND PROSPECTS OF FURTHER RESEARCH

The developed structure of the interaction of participants in the educational process in the educational environment of STEM-oriented learning provides the opportunity for practical construction of space that contributes to solving the following tasks: making scientific and technological careers attractive for young people, the integration of business and education with a view to creating scientific interactions of all participants of STEM-education and support of innovative ideas in the society.

The article defines the educational environment of STEM-oriented learning as a set of objective external conditions and social factors (administrative and management component, technological facilities, human resources) that influence the formation of the scientific and technological outlook of the individual. It is a necessary component for the successful functioning of STEM-education. The conditions (provision of scientific and methodological support, cooperation, development and popularization STEM-education) that are necessary for the construction of the educational STEM-environment are established.

Design of the vertical and horizontal connections between participants in such educational and scientific process gives a vision of future professional activity and creates a community of strong collaboration. One of these conditions is interaction at all levels of the educational system. Support of innovative ideas and research atmosphere in the society make scientific and technological careers more appealing to young people.

The model which implements the scheme of interaction between participants (students, teachers, tutors) in STEM-oriented educational environment serves as a platform for establishing cooperation between different participants in the educational process. Strengthening the interaction between education, science, technology and business is possible only with the construction of a society ready to collaborate on solving real social and economic problems. The main role in this process is given to professional training of qualified personnel, the creation of STEM-centres, and the dissemination of STEM-education ideas.

In the future, it is planned to continue research on the development of STEM-education in the areas of developing syllabi of new courses and integrating them into the educational process in order to create conditions for the implementation of the innovative potential of youth. We also see the prospect of further research in theoretical substantiation and development of a system for assessing the educational STEM-environment.

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ПОБУДОВА ОСВІТНЬОГО СЕРЕДОВИЩА STEM-ОРІЄНТОВАНОГО НАВЧАННЯ

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Анотація. У статті розглянуто вплив вимог ринку праці до системи освіти в контексті технічного розвитку суспільства і зміни економічного розвитку держави. Також розглянуто основні напрями зміни Європейської освітньої політики та їх формалізація у вигляді рамкових компетентностей. Проведено аналіз ситуацій в інших країнах з впровадження STEM-освіти та особливостей формування і розвитку STEM-орієнтованого освітнього середовища (освітнього STEM-середовища), який дозволив визначити структуру взаємодії учасників освітнього середовища STEM-орієнтованого навчання, серед яких: адміністративно-управлінська складова, співробітництво між освітою та бізнесовими структурами, науково-методична підтримка, технологічний фактор, популяризація та людський фактор. У роботі дано визначення освітнього середовища STEM-орієнтованого навчання. Розглянуто практики організації освітнього простору в Україні та інших країнах. Це дало можливість визначити структуру взаємодії учасників в освітньому STEM-середовищі. Відповідно до кожного з пунктів цієї структури було показано особливості реалізації їх у нашій країні: визначено кроки, які були зроблені в Україні для вирішення питання впровадження STEM-освіти на законодавчому рівні, сформовано перелік заходів, спрямованих на популяризацію та підтримку STEM-освіти, а також поширення цих ідей, зроблено перелік уже існуючих розробок і практик впровадження. Встановлено умови, дотримання яких передбачає побудову освітнього STEM-середовища. Також у статті представлено модель освітнього середовища STEM-орієнтованого навчання (на прикладі STEM-школи Херсонського державного університету). Наведено характеристику проєктної діяльності вчителя і учнів у розрізі етапів впровадження STEM-освіти. Також наведені приклади міждисциплінарних проєктів, реалізація яких потребує наявності в учителя хорошої теоретичної бази з математики, фізики, технологій та програмування.

Ключові слова: STEM-освіта; освітнє середовище STEM-орієнтованого навчання; діяльність учителя; взаємодія; популяризація STEM; структура взаємодії; модель функціонування.

ПОСТРОЕНИЕ ОБРАЗОВАТЕЛЬНОЙ СРЕДЫ STEM-ОРИЕНТИРОВАННОГО ОБУЧЕНИЯ

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Аннотация. В статье рассмотрено влияние требований рынка труда к системе образования в контексте технического развития общества и изменения экономического развития государства. Также рассмотрено основные направления изменения Европейской образовательной политики и их формализация в виде рамочных компетенций. Проведен анализ ситуаций в других странах по внедрению STEM-образования и особенностей формирования и развития STEM-ориентированной образовательной среды, который позволил определить ключевые компоненты, необходимые для построения образовательной

среды STEM-ориентированного обучения, среди которых: административно-управленческая составляющая, сотрудничество между образованием и бизнес-структурами, научно-методическая поддержка, технологический фактор, популяризация и человеческий фактор. В работе дано определение образовательной среды STEM-ориентированного обучения. Рассмотрены практики организации образовательного пространства в Украине и других странах. Это позволило определить структуру взаимодействия участников в образовательной STEM-среде. Согласно каждому из пунктов этой структуры показаны особенности реализации их в нашей стране: перечислены шаги, которые были сделаны в Украине для решения вопроса внедрения STEM-образования на законодательном уровне, сформирован перечень мероприятий, направленных на популяризацию и поддержку STEM-образования, а также распространение этих идей, приведен перечень уже существующих разработок и практик внедрения. Установлены условия, соблюдение которых предусматривает построение образовательной STEM-среды. Также в статье представлена модель образовательной среды STEM-ориентированного обучения (на примере STEM-школы Херсонского государственного университета). Приведена характеристика проектной деятельности учителя и учащихся в разрезе этапов внедрения STEM-образования. Также приведены примеры междисциплинарных проектов, реализация которых требует наличия у учителя хорошей теоретической базы по математике, физике, технологиям и программированию.

Ключевые слова: STEM-образование; образовательная среда STEM-ориентированного обучения; деятельность учителя; взаимодействие; популяризация STEM; структура взаимодействия; модель функционирования.

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