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MODEL OF ORGANIZATION OF THE UNIVERSITY ECOSYSTEM FOR THE DEVELOPMENT OF STEM-EDUCATION

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The development of artificial intelligence systems in the near future will lead to a reduction in routine, template work. The toolkit changes in most professions. There is a need for a quick retraining of a specialist and the use of computer systems. Nowadays, separate devices and systems have been created that can solve some of the problems that appear in everyday life. Therefore, STEM education is one of the directions that is in demand in society.

During last few years in Ukraine there has been a rapid increase in the number of technical groups – robotics and programming. All of them are different of organization, types of classes, target audience. We made an effort to summarize the information received on this issue. In this article we analyze the situation on the market of educational services of the STEM-direction in Ukraine and in other countries, consider the existing technical and methodological support of STEM-education, as well as the experience of creating a STEM-school based on the post-graduate education center of Kherson State University. We describe the steps needed to create such a structure, its place in the educational system. Also we describe the experience of developing the material for the development of curricula, a series of events that promote the attraction of researches, and the introduction of digital technologies in the educational process.

The pace and breadth of the STEM movement, as well as the support and interest of the state in Ukraine, show that, within three to five years, STEM-based methods and tools will be almost fully integrated into school curricula. At the same time, the material and technical support, as well as the professional development of teachers, are crucial for the pace of integration.

The creation of a STEM center at the university, in which both future engineers and future teachers are trained, makes it possible to create a harmonious ecosystem in the region for the development of new technologies in the region.

***Keywords**: robotics, educational robotics, STEM, ICT, LLL, robotics after school programs, pre- and in-service teachers, certification, standards, post-secondary education.*

Introduction

The reform of education, which began two years ago, declared the STEM-education as the main scientific and technical direction. During 2017, with the support of the Ministry of Education and Science of Ukraine, two massive web-STEM-inars for teachers and an olympiad on robotics were held. In addition, numerous hackathons, festivals and competitions on robotics, scientific picnics and weekly codes are conducted under the auspices of leading companies such as Lego, Microsoft, Cisco, and others.

Six locations have been created in Kherson last year (STEM-school, Cool School, IT School, courses of BrainBasket Foundation, Main Academy Kherson, Kherson Workshop) offering courses on programming and robotics for children aged six and over. For comparison: in 2016, there was only one school of early development, which was conducted for children 4 – 6 years of occupation using Lego WeDo 2.0. (RT-Studio "ISLAND"), 1 course for children from 10 years of age RoboHouse (Lego WeDo 2.0, Arduino and C ++ programming), 1 computer school "Step" for children from 10 years old (Lego Mindstorm robotics, Arduino and programming).

Classes in robotics require a significant material and technical base, special technical knowledge and techniques, so the number of circles in this direction in comparison with the courses of programming is less. Also, the limiting factor is the lack of techniques. In general, most of the activity classes now use existing Lego Education classroom training techniques, which are almost un-changed. For other robotic designers, each organization has its own developments.

The article describes plans for occupations in robotics and programming that allow you to plan and do similar courses in your organization. So we want to share the features we met during their organization.

Related Work

Current status of STEM education. The acronym STEM — science, technology, engineering, and math — includes core occupations in the hard sciences, engineering, and mathematics, but there is often less consensus about whether to include other professions such as educator, manager, technician, health-care professional, or social scientist.

STEM occupations are divided in several groups:

- computer and math occupations – computer scientist and systems analyst, computer programmer, computer software engineer, computer support specialist, database administrator, network and computer systems administrator, network systems and data communications analyst, mathematician, statistician, operations research analyst, miscellaneous mathematical science occupation;
- engineering and surveying occupations - surveyors, cartographer; aerospace, agricultural, bio-medical, chemical, civil, computer hardware, electrical and electronic, environmental, industrial, marine, mechanical mining and geological, nuclear, petroleum engineers;
- physical and life sciences occupations – agricultural and food scientist, biological scientist, conservation scientist and forester, medical scientist, astronomer and physicist, atmospheric and space scientist; physical, agricultural, biological, chemical, geological, nuclear technicians;
- STEM managerial occupations - computer and information systems manager, engineering man-ager, natural sciences manager. [1]

The World Economic Forum report “The Future of Jobs” launched during the Annual Meeting 2016 in Davos, looked at the skills for the future. It lists top 10 skills for 2020: complex problem solving, critical thinking, creativity, people management, coordinating with others, emotional intelligence, judgment and decision making, service orientation, negotiation, cognitive flexibility. Development of these skills is also important for STEM professions. [2]

The USA regularly pays attention to the development of STEM. For example, the Obama administration "Educate to Innovate" campaign (2009) was aimed to motivate and inspire students to excel in STEM subjects. It also addresses the inadequate number of teachers skilled to educate in these subjects. The Obama administration's 2014 budget invests $3.1 billion in federal programs on STEM education, with an increase of 6.7% over 2012. The investments will be made to recruit and support STEM teachers, support STEM-focused high schools with STEM Innovation Networks. Donald Trump is also nudging young adults to consider STEM careers. In September, 2017, he signed a memo dedicating $200 million dollars a year for technology education grants for women and minorities.

U.S. Bureau of Labor Statistics shared information about STEM occupations, in which most of the largest STEM professions were related to computers and information systems. With employment of nearly 750,000, applications software developers [14] were the largest STEM occupation. Computer user support specialists and computer systems analysts each accounted for over a half a million jobs.

USA has different programs and competitions to improve STEM skills [10, 11, 12]:

- "Student Spaceflight Experiments Program" – it is a program that tries to let children do science in a real world context and leverage the inspirational nature of the Space Program and the Inter-national Space Station;
- "TOMATOSPHERE" – it supports and benefits the space program by investigating which type of seeds would be most suitable for long duration spaceflight, while at the same time inspiring students to pursue STEM fields and exposing them to real spaceflight research;
- "The FIRST Robotics Competition" – it is an exciting, nationwide competition that teams professionals and young people to solve an engineering design problem in an intense and competitive way;
- "NASA Swarmathon University Challenge" - Swarmathon students gain experience with code integration, hardware testing, software engineering, project management and team collaboration critical to their future success in robotics and computer science;
- "MUREP Aeronautics Scholarship and Advanced STEM Training and Research Fellowship" – AS&ASTAR provides fellowship awards for individuals pursuing or planning to pursue graduate studies leading to Masters and Doctoral degrees in relevant NASA-related disciplines at accredited U.S;
- "MUREP Aerospace Academy" – MAA increases participation and retention of historically underserved and underrepresented K-12 youth in the areas of STEM; its goals are to improve STEM literacy by engaging students and teachers through the integration of emerging technologies, educate students utilizing a STEM curriculum that meets national STEM standards aligned to NASA's mission directorates;
- "MUREP Institutional Research Opportunity" – MIRO is established to strengthen and develop the research capacity and infrastructure of Minority Serving Institutions, or MSIs in areas of strategic importance and value to NASA's mission and national priorities; overall, MIRO awards aim to promote STEM literacy and to enhance and sustain the capability of institutions to perform NASA-related research and education, which directly supports NASA's four Mission Directorates.

Most European countries have national strategies or action plans devoted to STEM education. The EU STEM Coalition is a Europe-wide network of national STEM platforms: organizations established by governments to increase the number of STEM graduates and reduce skills mismatch. Its aim is to bridge the skills gap by having a national STEM strategy in place in all EU member states. It includes such key characteristics of the platform approach as the close co-operation between government, education and industry, and strongly regionalised implementation. The main challenge is to develop and implement a strategy that addresses both the quantitative and qualitative dimension of skills mismatch throughout the entire education chain – from primary education all the way to the labor market.

European science society also has different events and programs, for example:

- "Robotex" – it is Europe's biggest robotics festival; during the event there are various exciting activities for kids, students, robotics enthusiasts and even grandparents;
- "Science on Stage Europe" - the European network for science teachers and educators; it believes that a good way to encourage schoolchildren to consider a career in science or engineering is to motivate and educate their teachers;
- "European Schoolnet" – it is the network of 34 European Ministries of Education, based in Brussels; its aim is to bring innovation in teaching and learning to key stakeholders: Ministries of Education, schools, teachers, researchers, and industry partners.

Women's participation in STEM. In spite of significant improvements in these latter days, education is not universally available and gender inequalities persist. A small number of girls and women in STEM education and careers is a loss for all.

False perceptions about women's aptitude, interest and experience in STEM are holding back progress in science, and society. Several myths exist about women in STEM fields:

- girls are bad at mathematics – there is no innate gender difference in mathematics ability;

- most women are not interested in careers in engineering, physics and ICT – women's participation in STEM increases in inclusive cultural environments;
- the gender pay gap doesn't exist – women in STEM earn less than their male colleagues. [4]

Despite a commonly held biased belief that women are not made for technology, 40% of LinkedIn Top Voices 2017 in Technology are women. They were featured many across LinkedIn's Pulse channels and delivered high-quality content on a range of topics in the tech industry [5]

Among the STEM disciplines, the lowest female participation rates are observed in information, communication and technology (ICT), engineering, manufacturing and construction, natural science, mathematics and statistics. Women leave STEM disciplines in disproportionate numbers during their studying in higher education institutions, in their transition to the world of work and even during their career cycle.

UNESCO shared chart, which demonstrates human resources in R&D. As for 2015, a number of female researchers is 46.3% in Ukraine. Also they highlighted several facts:

- 17 women have won a Nobel Prize in physics, chemistry or medicine since Marie Curie in 1903, compared to 572 men;
- only 28% of all of the world's researchers are women today;
- about 35% of higher education students studying STEM subjects are women.

Although global averages mask significant regional and country differences, we can see world proportions of female students enrolled in natural science, mathematics and statistics studies [6].

Nowadays this topic is in need of urgent attention all over the world. A significant gender divide is observed from an early age to a mature one.

Early childhood can play a key role in STEM engagement. Toys and games are very important for children. But gender issues also arise in this field. Consider this as an example of Lego. Though Lego has long trumpeted themselves as gender neutral, they began to tailor more of their products to girls.

90% of Lego's consumers were boys in 2011. It took four years of research to figure out how to address the girls' market, how to attack it the right way. Consequently, Lego Friends were very successful. They were five dolls with storylines and sets that encourage girls to build karate studios, beauty shops and vet clinics. As a result, sales to girls tripled in just that year. The success of the girl-centric Lego Friends has led to little girl dolls popping up in construction sets all over the place. Consumers said that was great for developing STEM skills for girls.

But this was not enough. In 2014 a new Lego kit came in. A female scientist set had figurines that study dinosaurs, map the stars, and perform lab experiments. Since then the company includes other women in STEM and non-traditional fields. When girls are given more encouragement in the STEM fields, they become more likely to pursue careers in these areas.

Also digital toys and games – specifically, ones that teach coding – are increasingly targeted to girls. GoldieBlox is the award-winning worldwide children's multimedia company through the integration of storytelling and STEM principles, creates toys, books, apps, videos. Its goal is to inspire more women to pursue STEM fields. If we teach girls early on that they're capable they won't feel as intimidated by entering these male-dominated fields.

Recently Microsoft made research that has revealed that most girls' positive views may change in subsequent years. The technology company asked 11,500 women between the ages of 11 and 30 in 12 European countries about their attitudes to STEM. Results showed that most girls become interested in STEM at the age of 11-and-a-half but this starts to wane by the age of 15 [7].

Only 42% said they would consider a STEM-related career in the future. 60% admitted they would feel more confident pursuing a career in STEM fields if they knew men and women were equally employed in those professions. About 57% of the young European women that Microsoft surveyed said that having a teacher who encouraged them to pursue STEM would make it more likely for them to follow that career path [8].

There are a large number of organizations, programs and societies that provide opportunities for girls and women:

- "Techbridge Girls" – it inspires girls to discover a passion for technology, science and engineering through hands-on learning;
- "Django Girls" – a volunteer run organization and a community that empowers and helps women to organize free, one-day programming workshops by providing tools, resources and support. During each event, 30 – 60 women build their first web application using HTML, CSS, Python and Django;
- "Girls Who Code" – it offers learning opportunities for students to deepen their computer science skills;
- "Girls' Programming Network" – this program is targeted at high school girls interested in IT, particularly those interested in learning to program or improving their software development skills;
- "Made with Code" – it helps to encourage passion for science and technology through coding in teen girls;
- "Girl Develop It" – it is an organization that provides affordable programs for adult women inter-ested in learning web and software development;
- "TECHNOLOchicas" – it is an initiative designed to raise awareness among young Latinas and their families about opportunities and careers in technology;
- #MakeWhatsNext workshops – events with role models for girls that are arranged by Microsoft to engage young girls in STEM and to reduce gender gap;
- "National Center for Women & Information Technology" – a change-leader network represents the largest, rapidly growing community in support of improving diversity and inclusion in computing; it provides technical girls and women with ongoing engagement, visibility, and encouragement for their computing-related interests and achievements from high school through college and into the workforce.

Ukraine also tries to increase women's participation in STEM. In October, 2017, a hackathon called "Hack for Good: Increasing the number of girls in STEM through IT-technology" was held in Kiev on the initiative of project "STEM girls". Hack4Good is the first National Hackaton for Girls in Ukraine (18 – 24 years old). Its aim is to increase the number of girls in STEM through IT technology. According to U-report / UNICEF, 23.2% of girls are uncertain in their strengths, and 17.1% believe that STEM is for male. In contrast, 48% of respondents believe that the destruction of gen-der stereotypes will motivate girls to choose their careers in science and technology.

So, "STEM girls" is aimed at overcoming gender stereotypes when choosing a profession and in-creasing girls' faith in their own abilities and the opportunity to build a STEM career in Ukraine. This project created the "TOP 20 Inspiring Women in STEM" community, that is a unique community of women in Ukraine who have made a successful career in the field of science and technology. Among them there are top managers of IT and technical companies, academics, representatives of ministries, universities and public organizations. These women meet high school female students in different parts of Ukraine. They also launched a national competition "Why do I choose a STEM career?". Its winners will be given mentor support within 4-5 months.

Proceeding from the list, the majority of organizations first of all try to involve girls in programming. This is not surprising, since the "The Diversity Gaps in Computer Science: Exploring the Underrepresentation of Girls, Blacks, and Hispanics" report shows that female students are less interested and less confident they could learn computer science. The lesser awareness, exposure, interest, and confidence could be keeping girls from considering learning information technology. Also if parents believe that an inherent lack of interest is the reason girls are not as prevalent in computer science, they may be less likely to encourage their children to learn it [13].

Despite the above information, some roles come much closer to gender parity, and a few roles are clearly the domain of women. Female workers predominate in such occupations as psychologist, veterinarian, optician, and clinical lab tech. But men in these professions are not rare. Regarding the health care system in the most extreme niches, only 1 of every 20 – 30 professionals are men. These professions are new well-paid employment horizon for men. Among them there are dental

hygienist, dietitian, nutritionist, genetic counselor, surgical technologist, registered nurse, nurse practitioner, licensed practical and licensed vocational nurse. In these professions current representation of women is more than 85% [7].

Experimental Settings

Implementation of the new educational policy involves the introduction and development of STEM-education in Ukraine, aimed at the innovative development of the subjects of the natural-mathematical cycle, research work in educational institutions. Successful implementation of STEM-education requires systemic decisions and implementation of many prerequisites, among which the following:

- The administrative and management component is the organizational effort to implement methods in teaching and management, as well as the reorganization of the educational space
- Cooperation - the establishment and development of partnerships between education and business, production. It will help solve current problems, implement innovative ideas and provide practical training.
- Provide scientific and methodological support - development of curricula and courses of choice, testing and implementation of new approaches to educational activities. Different stages of implementation of STEM-education require research in the field of determining the content and technologies for their implementation.
- Technological factor - the use of training designers, robots, which help in practice to implement innovative ideas, create prototypes of devices. This factor is the key to the formation of STEM education, but it is not the only one.
- Popularization of STEM-education - attracting young people to solving scientific and technical problems through a system of centers, laboratories, circles, science museums, etc.; through the holding of festivals, contests, quests, etc.
- Human resources are the most important factor. A fundamental role in ensuring STEM education in human resources is through continuing training for specialists to adapt and provide basic skills. Educated, better trained and knowledgeable specialists help strengthen innovation.

However, there are problems with the introduction of wall-education. The formation of skills necessary for STEM professions is fragmentary in different lessons and circles. In addition, students do not readily choose traditionally difficult mathematics and physics for mastering. And despite the high level of salaries and the demand for specialists in the STEM profession in the labor market, most school leavers who entered universities choose a liberal arts education. Stem can be perfectly realized as a circle work, but for effective development of this direction it is necessary to build an ecosystem in the region, combining different participants: parents, pupils, educational institutions, stakeholders and business. In our case, Kherson State University became the foundation for building the ecosystem.

In order to raise the interest of STEM it is necessary to disseminate and popularize these ideas among children, parents, young people, and teachers. Teachers are given a special role here - to show the attractiveness of scientific research and discoveries. But there is a problem promoting the ideas of STEM among teachers. Not all of them are ready for the implementation of interpersonal connections in the classroom work. There is a problem of attracting technological innovations and the teacher's unwillingness or fear of using them in lessons. This problem can be influenced by regular events devoted to popularizing science. In Ukraine, there is now a powerful movement to attract young people to scientific and technological activities through the introduction of STEM technologies in the educational process and in extracurricular work. Research centers and advanced school establishments develop programs of courses in robotics, held festivals of innovative technologies, robotics competitions. Examples include Kiyv Mini Make Fair, IT Festival 4.0 (Flight Academy of the National Aviation University, Kropyvnitsky), FIRST LEGO League and FLL Jr. festivals. (Innovative Educational Technologies), Rotational Competition (ORT), competition Ro-

botronica and ROBRICE (Odessa National Academy of Food Technologies), Youth IT Festival Spring Soft (Kropivnitsky), Tech Fest Festival and BestRoboFest in the Dnipro, scientific picnics (in different cities of Ukraine), the Olympiad on robotics AsimovOlympics (Kharkiv-Kiev-Odessa), the All-Ukrainian Festival of Innovations, Sikorsky Challenge (KPI).

In April 2017, a STEM-school was created on the basis of the Post-Graduate Education Center of Kherson State University. The objectives of the school are:

- support of scientific, technical and engineering component in additional education of students and students;
- increasing the availability of natural and engineering laboratories for schoolchildren, students and teachers, access to up-to-date equipment and innovative programs;
- motivation of senior students to continue education in scientific, technical and engineering spheres;
- popularization of inventive and research activities;
- project-oriented study of students and students under the guidance of young scientists and engineers;
- increase in the number of students, future entrants, who are interested in technical creativity, new technologies, programming, research in related industries;
- formation of the expert community in the field of introduction of STEM-education, including improvement of the skills of teachers in the direction of STEM-education, in particular robotics;
- creating conditions for the adaptation and implementation of innovative programs created with the participation of masters, postgraduates, KSU (Kherson State University) scientists, leading IT companies, enterprises in the programs of additional education of students, the curriculum of the KSU.

The school conducts educational, informational and methodological, organizational and mass work, aimed at improving programs, content, forms and methods of activity of groups in the direction of STEM-education. The school is the base for passing the production and pedagogical practice of students of pedagogical specialties. In the summer, on the basis of the school are held scientific courses for children. These courses are popular and children who first were there, then attend classes during the year.

Since school was created recently, we present the preliminary results obtained on the basis of the introduction of new techniques and technologies in the educational process for two a year.

Experimental Results

In fact, the work of this school began in March 2017, with the training of one group of children aged 6 – 10 years. During the time of existence of the STEM-school there were 5 changes to the summer camp for schoolchildren of 6 – 12 years old, 9 methodical seminars for teachers of Kherson and the region. In addition, at the STEM-school there are 7 groups of students and a group of engineering students trained throughout the year.

In order to achieve the tasks, a program of training for the summer courses, a program of training for the year, a program of a seminar for teachers was developed.

Summer courses program. For children aged from 6 to 16 years, a summer-intensive program in programming and robotics was developed. This program was implemented at the summer STEM-school in 2017. One change lasted five business days, so the program is designed for four hours of training within five days of training. These four hours include: 1 hour of robotics (Lego WeDo 2.0.), 1 hour of programming (Scratch), 1 hour of physics in experiments, 1 hour of mastering (technical creativity).

The main criteria for selecting activity activities were:

- Science
- Brightness of the demonstration.
- Relevance, binding to real situations, needs.
- Easy to implement. Ability to create a finished product in one hour.

For occupations in robotics, methodological materials were developed specifically for Lego WeDo 2.0 were used. During five lessons, the children managed to master the programming environment, the operation of sensors, the construction of structures and at the last lesson, they could independently create their own design. In each of the tasks, the design approach was used, so each of its own de-sign took the stages of demonstration and protection. The kids discussed about the model they created and about the functions it performed. Among the presented models, the majority were modifications of already passed designs, but there were also unique structures for irrigation fields, mechanisms for sampling soil on other planets, and others.

Course program throughout the year. The course program for the year should be different from the summer intensive program. Above all, these lessons should be consistent and scientifically sound. The child must not only create a mechanism, but also understand the advantages of a particular design, possible alternatives to another construction. It is also important for such lessons to formulate a holistic notion of scientific research and the process of creating a software product.

Creating robots requires not only knowledge of physics, technology. Initial knowledge of algorithmization and programming is also necessary. Therefore, the course, which was conducted during the year, was constructed on the principle: 1 lesson of robotics, 1 lesson of programming per week.

For occupations on robotics, several variants of designers were considered (justification of the choice in the article [9]).

1. Lego for Education (WeDo 2.0, MINDSTORMS EV3) – for junior groups.
2. Arduino – for senior groups.

For classes on programming, used Scratch and C ++.

The course Lego WeDo2.0 offers the use of educational constructors LEGO and hardware-software as a tool for teaching students in the design, modeling and computer management in Lego-design classes.

Robotics of LEGO combines the possibilities: the development of fine motor skills by working with small parts of designers; mathematics skills (comparing parts by size); skills of construction, familiarity with the fundamentals of mechanics and propedeutics of engineering education; first programming experience; teamwork (the robot is done by 2-3 pupils); skills of presentation (when the project is completed, it is necessary to present it).

The purpose of Lego Wedo 2.0 is: the organization of employment of schoolchildren in after-hours, the logical thinking development; construction skills development; motivation to study the sciences of the natural-science cycle: Physics, Computer Science (programming and automated control systems) and Mathematics. At each lesson the following tasks were realized: familiarization with the basic principles of mechanics; familiarization with the basics of programming in the Lego Wedo 2.0 environment; development of the ability to work according to the proposed instructions; development of the ability to do the task creatively; development of the ability to bring the solution of the problem to the working model; the development of the ability to express thoughts in a clear logical sequence, defend the point of view, analyze the situation and independently find answers to questions through logical reasoning, development of the ability to work on a project in a team, effectively allocate responsibilities, training for Lego-design competitions.

The result of the work of students in classes Lego Wedo 2.0 is the creation of real models of robots; control behavior of robots with the help of simple programming; practical application of design, engineering and computing skills.

In the classroom, the project methodology was used. The topics of the projects were related to the modeling of animals (frog, bee, crocodile) and their behavior; building models of modern machines and mechanisms, studying the principles of their work (car and truck, helicopter, crane, etc.) and programming robots to carry out their tasks. The important aspect of the implementation of each project is research activity.

Five teams of schoolchildren took part in the All-Ukrainian Robotics Olympiad for the WRO WeDo 2.0 Primary School held in the framework of the STEM ROBOTICA Festival in Kyiv in May 2018. Students have demonstrated high achievements in robotics and programming, fulfilling all the tasks and obtaining maximum marks.

Teacher Training Workshop. The quality of the implementation of STEM education is largely determined by the competence and level of professional activity of scientific and pedagogical workers, as they actively use the latest pedagogical approaches to teaching and evaluation, innovative practices of interdisciplinary education, methods and teaching methods with a focus on the development of research competencies. In this regard, recent attention has been paid to the implementation of quality teacher training, the implementation of long-term initiatives for their professional development in advanced training courses.

Today, in Kherson and the Kherson region, the situation has arisen when educational establishments have the opportunity to purchase (or have already purchased) kits for classes in robotics or modern equipment for scientific and technical research, but teachers and heads of groups are not ready to introduce new technologies into the educational process. The technology market has been developing quite rapidly in recent years, and it takes a lot of time to track new developments and trends.

Successful development of STEM education is carried out through collaboration in the learning process between schools, higher education institutions, postgraduate education institutions and STEM centers.

That is why our STEM-school developed a program of workshops for school teachers to familiarize them with the main areas of scientific and technical research that has become popular in recent years.

In 2017, on the basis of the STEM-school of KSU, we conducted nine workshops and master classes (including two outgoing ones) for implementing STEM-education for teachers of schools in the city of Kherson and the Kherson region, and for the students of courses for the training of teachers of physics, mathematics, Informatics and Technologies "Kherson Academy of Continuing Education". The trainings introduced teachers to the normative basis, content and ways of introducing STEM-education in educational institutions.

The Workshop’s program included topics:

- lecture "STEM in the world and in Ukraine".
- lecture "Information Technologies at STEM".
- Lego WeDo 2.0 master class.
- Arduino master class.

In the course of design and research activities, teachers received examples of methodological materials that create a motivated, exciting educational environment for the formation and development of critical and creative thinking skills among students through the educational solutions of LEGO Education and Arduino Robotic Solutions.

As a result of the theoretical analysis of methodological, technological and managerial problems in the implementation of STEM-education, an online on-line training course for teachers was developed. STEM-Seminar, which includes:

- Normative base of STEM-education;
- Software catalog;
- Methodical guidelines for using the Scratch environment to learn the basics of algorithmization and programming;
- Methodical recommendations for the study of physics, mathematics and informatics with the help of robotic solutions LEGO Education;
- Guidelines for the course on robotics on the Arduino platform;
- Catalog of author's training programs in robotics and computer simulation;

- Catalog of STEM-organizations, STEM-festivals and personal pages of teachers implementing STEM-technologies.

In the period from September to December 2017 we conducted a survey of Workshop's participants. Teachers filled out two questionnaires available online: in-line questionnaire and feedback.

We received 318 questionnaires for the incoming poll. The seminars were attended by teachers from 76 different schools, educational organizations of the city (27 institutions / 117 people) and region (49 institutions / 201 people).

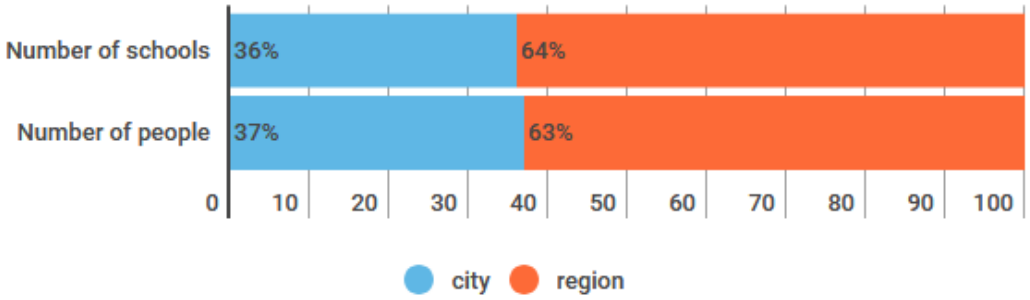

Fig. 1. Distribution of Workshop's participants.

Most of the teachers teach of the natural-mathematical cycle (physics, mathematics, computer science, astronomy). A significant number of them teaches several subjects. For example, a mathematics teacher also teaches physics and computer science.

Teachers who teach mathematics, physics, computer science were the most – 76%, teachers of other subjects – 24%. Most of the participants teach STEM (91%), others were philologists or methodologists (9%). Also, almost all teachers conduct additional classes or manage the work of circles, that is, they are quite active in their professional activities.

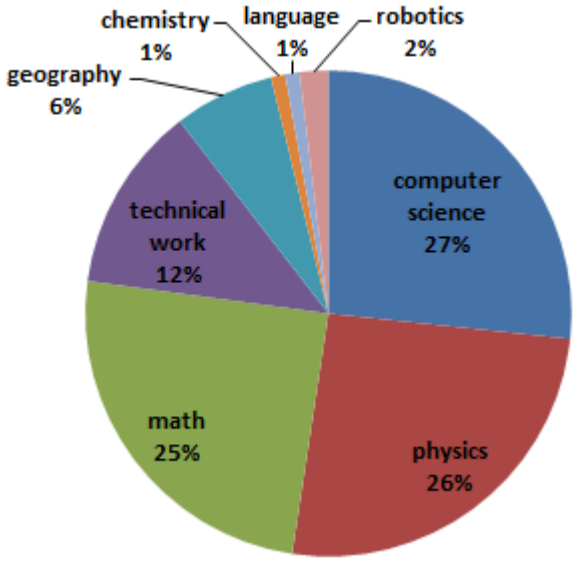

Fig. 2. Number of teachers in directions.

A larger number of teachers at the seminars have already met the notion of STEM education (55%), but also a large proportion of people not yet familiar with this term (43%). Others have already used or sought ways to implement STEM education (2%) to a greater or lesser extent.

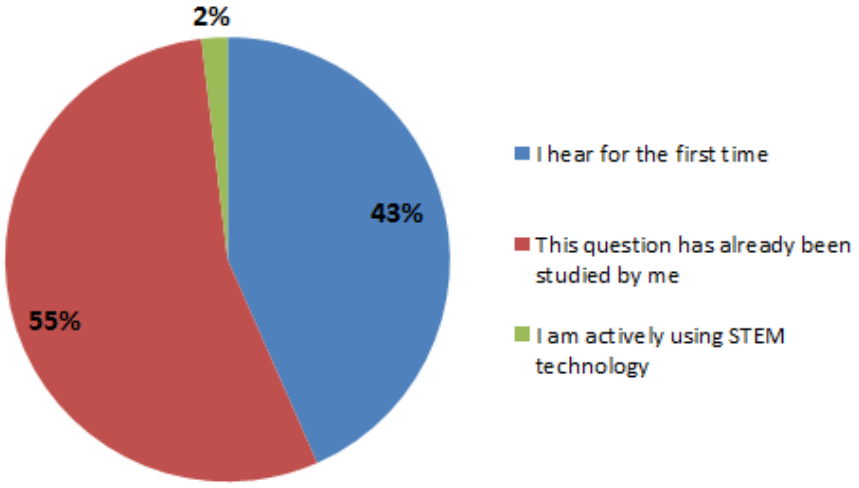

Fig. 3. Level of knowledge of learners about STEM.

Much of the teachers indicated that they had STEM-type circles (51%) in their school. But, in part, in the questionnaires teachers wrote that there are no circles. This is more likely due to the fact that there is no school of robotics in the school.

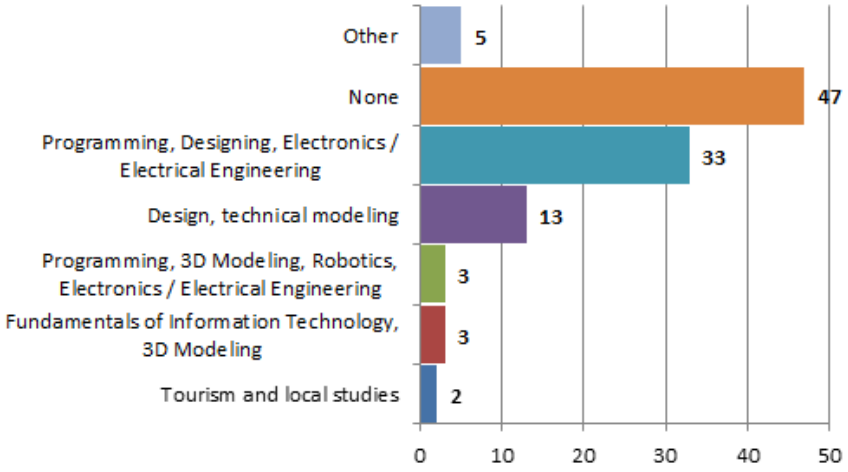

Fig. 4. The presence of clubs in schools.

To the question "What kind of circles would you like to set up at your school?" The respondents had the opportunity to specify several options. A significant number of responses came from the topics of seminars, programming, 3D simulation and robotics. But in addition to these responses, there were also answers (8%), such as web design, language courses, and more.

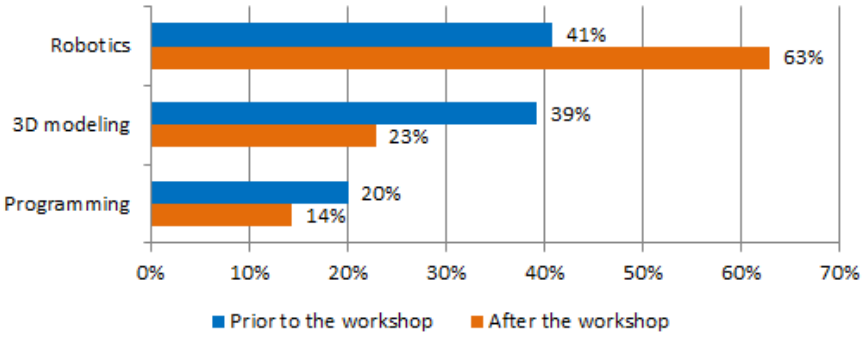

Fig. 5. Teachers' answers to the question "What circles would you like to start at your school?".

Interestingly, after the workshop there was an advantage in favor of robotics. Obviously, some teachers were convinced that the "complex" words are quite simple and understandable things that are easy to use in lessons.

To the question "What will you do to STEM-technologies?" The respondents had the opportunity to choose several different answers or write their own.

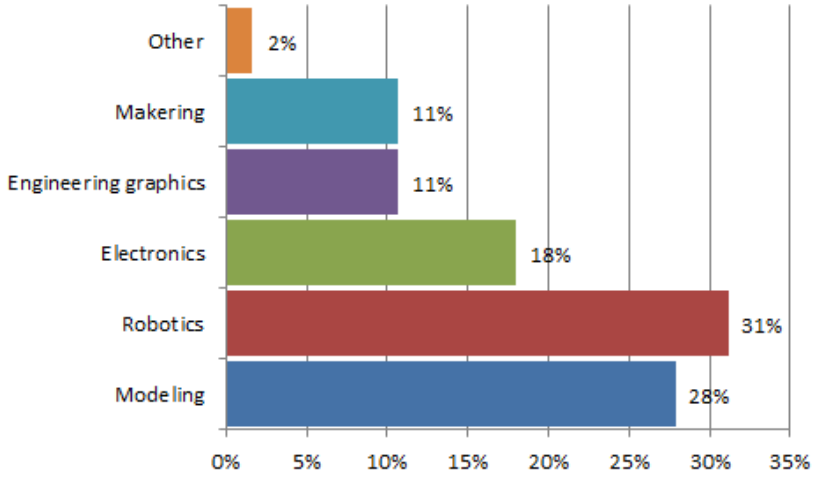

Fig. 6. Teachers' answers to the question "What will you do to STEM-technologies?".

Given the theme of the workshop, most people referred to modeling, robotics.

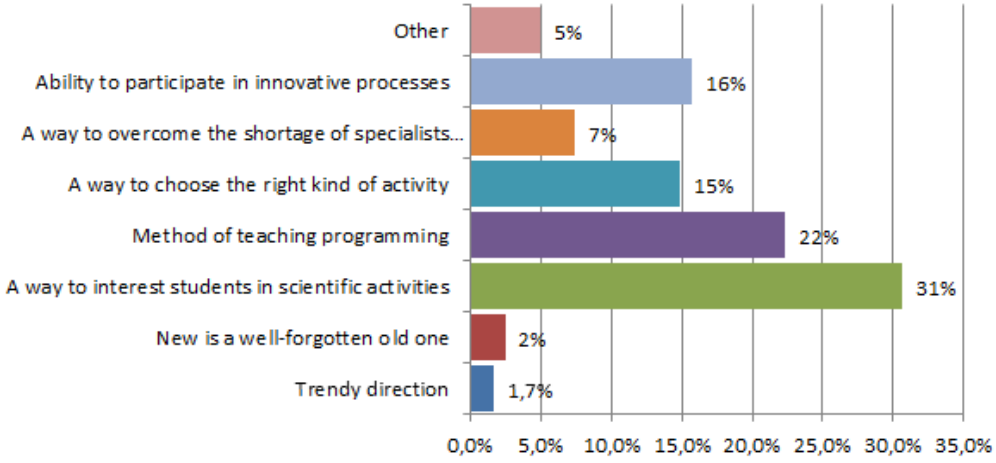

Fig. 7. What is STEM-education for you?

To the question "What is STEM-education for you?" The majority were optimistic and responded that it was an opportunity to interest students in scientific activities (97%), the ability to correctly choose a future profession (47%) and to be directly at the center of innovation processes (50%) Although part of the responses was less optimistic, noting that this is just a trendy direction and this is not a new topic (13%).

To the question "Which of the presented forms of implementation of STEM-education are more attractive to you?", The majority answered that it is better to hold these classes in circles or in computer science classes. At this time, not all teachers are ready to support and implement information technology in the educational process, and even less there is no sufficient practice of integrating their own subject with others.

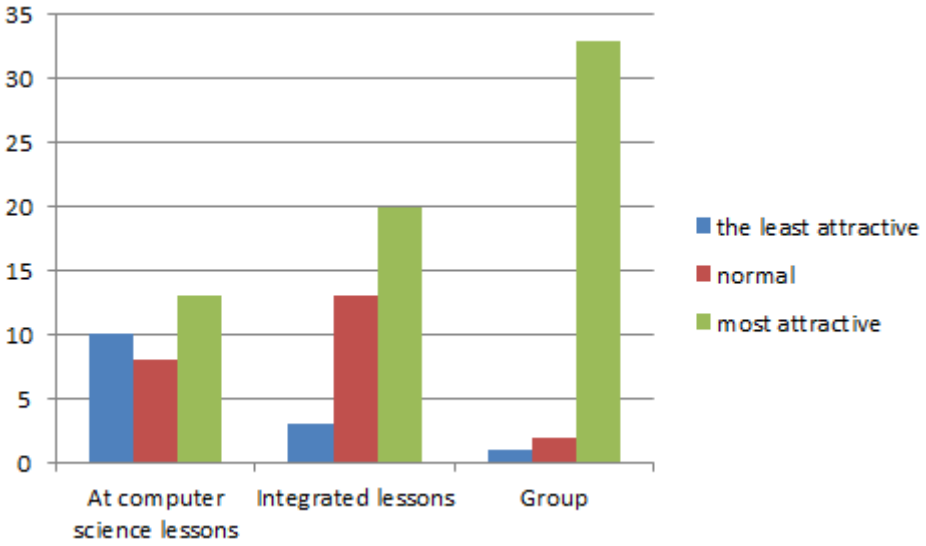

Fig. 8. Which of the presented forms of implementation of STEM-education are more attractive to you?

To identify problems with the implementation of STEM-technologies in education, the question was asked: "What resources do you need for the implementation of STEM?". The vast majority of teachers pointed out the problems of material difficulties. Moreover, if the computer technology of the school is almost normally provided, then the mechanical engineering is almost absent. But at the same time, teachers understand that the greatest difficulty will be the lack of methodological mate-rials.

Also in the questions of feedback was the question of whether one of the teachers would like to join the STEM-education classes and workshops in our city as a listener or a lecturer. Only 6% answered that they could take classes, while the remaining 96% indicated that they could join as listeners.

The program for students. Students of specialties Computer Science and Software Engineering study at Arduino's KSU STEM-School.

At junior courses, the study of robotics on the Arduino platform is an important motivation for mastering programming in C ++. That's why this year, STUD school students Kozyur Arina and Margarita presented their projects and entered the twenty winners of the video contest "Why do I choose STEM?" The STEM Girl Project. The works were selected by jury members, top 20 inspiring women at STEM 2017-2018, and STEM friends and followers on facebook and YouTube. Each participant has made great efforts and diligence to create interesting videos.

Conclusions and Future Work

The analysis showed the active development of STEM education worldwide. This approach corresponds to the growing needs of the society in engineering personnel, specialists in the field of information technology. Practical orientation, project activities, teamwork and research methods of STEM-education also contribute to the development of softskills. Therefore, the creation of centers for the development of this direction is very promising. Teachers can become agents of such changes in the districts of the region.

A survey conducted among teachers showed readiness of the teacher community for change. But most of them are more likely to wait for ready-made materials. Among them there is an understanding of the technological progress that has taken place over the past five years and its impact on the entire education system.

The plans developed should be used not as a copy but as a means to create a solid basis for future research, development and dissemination of STEM education in educational institutions. In the future, it is planned to expand work with other educational institutions and disseminate the practice of organizing STEM-education.

The pace and breadth of the STEM movement, as well as the support and interest of the state in Ukraine, show that, within three to five years, STEM-based methods and tools will be almost fully integrated into school curricula. At the same time, the material and technical support, as well as the professional development of teachers, are crucial for the pace of integration

The creation of a STEM center at the university, in which both future engineers and future teachers are trained, makes it possible to create a harmonious ecosystem in the region for the development of new technologies in the region.

REFERENCES

1. Noonan, R. (2017). Office of the Chief Economist, Economics and Statistics Administration, U.S. Department of Commerce. *STEM Jobs: 2017 Update (ESA Issue Brief #02-17)*. Retrieved from http://www.esa.doc.gov/sites/default/files/stem-jobs-2017-update.pdf.
2. Executive Summary (2016). *The Future of Jobs and Skills*. Retrieved from https://www.weforum.org/agenda/2016/03/21st-century-skills-future-jobs-students/.
3. Prinsley, R., Beavis, A.S. & Clifford-Hordacre, N. (2016). *Busting myths about women in STEM*. Retrieved from http://www.chiefscientist.gov.au/wp-content/uploads/OCS-paper-13.pdf.
4. LinkedIn (2017). *Women in Tech: 40% of LinkedIn Top Voices 2017 in Technology are women: What an achievement*. Retrieved from https://www.linkedin.com/pulse/40-linkedin-top-voices-2017-technology-women-what-muqbil-ahmar/.
5. UNESCO International Symposium and Policy Forum. (2017). *Cracking the code : girls' education in STEM*. Retrieved from http://unesdoc.unesco.org/images/0025/002534/253479E.pdf.
6. The Forbes (2017). *These 5 High-Paying, Fast-Growing STEM Professions Need More Men*. Retrieved from https://www.forbes.com/sites/metabrown/2017/10/29/these-5-high-paying-fast-growing-stem-professions-need-more-men/7/#930f06630c46.
7. Trotman, A. (2017). *Why don't European girls like science or technology?* Retrieved from https://news.microsoft.com/europe/features/dont-european-girls-like-science-technology/#W3R2xCWJmc HeAkSH.99
8. Kushnir, N., Valko, N. & Osipova, N. (2017). Review Of Trends, Approaches And Perspective Practices Of Stem-Education For Training Center Opening. *Informational Technologies in Education*, 31, 69-80.
9. Tomatosphere (2017). *Planting The Seed For Space Exploration*. Retrieved from http://amz.xcdsystem.com/4F14E44B-BC41-E69B-DFAF5A1B1627A0EA_abstract_File8313/Upload PDF_65_0710041118.pdf
10. NASA Education. (2018). *For Students*. Retrieved from https://www.nasa.gov/audience/forstudents/9-12/features/first-robotics-index.html#.UjdnIXfleSo.
11. NASA Education. (2018). *About NASA STEM Engagement*. Retrieved from https://www.nasa.gov/offices/education/about/index.html.
12. Google (2016). *Diversity Gaps in Computer Science: Exploring the Underrepresentation of Girls, Blacks and Hispanics*. Retrieved from http://services.google.com/fh/files/misc/diversity-gaps-in-computer-science-report.pdf.
13. United States Department of Labour (2015). *Occupational Employment Statistics*. Retrieved from https://www.bls.gov/oes/2015/may/stem.htm.

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МОДЕЛЬ ОРГАНІЗАЦІЇ ЕКОСИСТЕМИ УНІВЕРСИТЕТУ ДЛЯ РОЗВИТКУ STEM-ОСВІТИ

Розвиток систем штучного інтелекту в недалекому майбутньому призведе до скорочення рутинної, шаблонної роботи. Змінюється інструментарій у більшості професій.

Виникає потреба швидкого перенавчання фахівця і використання ним комп'ютеризованих систем. На сьогодні вже створені окремі пристрої і цілі системи, що здатні вирішувати частину проблем, які виникають у повсякденному житті людини. Тому STEM-освіта є одним із напрямів, затребуваних у суспільстві.

Останні декілька років в Україні спостерігається стрімке зростання кількості гуртків технічного спрямування, а саме із робототехніки та програмування. Усі вони відрізняються формою організації, видами занять, цільовою аудиторією. Нами здійснено спробу узагальнити отриману інформацію з цього питання. В статті зроблено аналіз ситуації на ринку освітніх послуг STEM-напрямку в Україні і за її межами, розглянуто існуюче технічне і методичне забезпечення STEM-освіти, а також досвід створення STEM-школи на базі центру післядипломної освіти Херсонського державного університету. У статті описано кроки, необхідні для створення такої структури, її місце в освітній системі. Також представлено досвід напрацювання матеріалу для розробки навчальних планів, проведення серії заходів, що сприяють залученню до науково-дослідної роботи і впровадженню цифрових технологій в освітній процес.

Швидкість розповсюдження STEM, а також підтримка та інтерес в Україні свідчать, що протягом трьох-п'яти років методи та інструменти на основі STEM будуть майже повністю інтегровані в шкільні програми. У той же час матеріальна та технічна підтримка, а також професійний розвиток учителів є вирішальними для темпу інтеграції.

Відкриття центру STEM в університеті, в якому навчаються як майбутні інженери, так і майбутні вчителі, дає можливість створити гармонійну екосистему для розвитку нових технологій у регіоні.

Ключові слова: робототехніка, освітня робототехніка, STEM, ІКТ, робототехніка позашкільних програм, викладачі до і після закінчення навчання, сертифікація, стандарти, післядипломна освіта.

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МОДЕЛЬ ОРГАНИЗАЦИИ ЭКОСИСТЕМЫ УНИВЕРСИТЕТА ДЛЯ РАЗВИТИЯ STEM-ОБРАЗОВАНИЯ

Развитие систем искусственного интеллекта в недалеком будущем приведет к сокращению рутинной, шаблонной работы. Меняется инструментарий в большинстве профессий. Возникает потребность быстрого переобучения специалиста и использование им компьютеризированных систем. На сегодня уже созданы отдельные устройства и целые системы, которые способны решать часть проблем, возникающих в повседневной жизни человека. Поэтому STEM-образование является одним из направлений, которое востребовано в обществе.

Последние несколько лет в Украине наблюдается стремительный рост количества кружков технического направления, а именно робототехники и программирования. Все они отличаются формой организации, видами занятий, целевой аудиторией. Нами предпринята попытка обобщить полученную информацию по этому вопросу. В статье сделан анализ ситуации на рынке образовательных услуг STEM-направления в Украине и за ее пределами, рассмотрены существующее техническое и методическое обеспечение STEM-образования, а также опыт создания STEM-школы на базе центра последипломного образования Херсонского государственного университета. В статье описано шаги, необходимые для создания такой структуры, ее место в образовательной системе. Также описан опыт наработки материала для разработки учебных планов, проведения серии мероприятий, способствующих привлечению к научно-исследовательской работе и внедрению цифровых технологий в образовательный процесс.

Скорость распространения STEM, а также поддержка и интерес в Украине показывают, что в течение трех-пяти лет методы и инструменты на основе STEM будут почти полностью интегрированы в школьные программы. В то же время материальная и техническая

поддержка, а также профессиональное развитие учителей являются решающими для темпа интеграции.

Создание центра STEM в университете, в котором учатся как будущие инженеры, так и будущие учителя, дает возможность создать гармоничную экосистему для развития новых технологий в регионе.

Ключевые слова: робототехника, образовательная робототехника, STEM, ИКТ, робототехника послешкольных программ, преподаватели до и после окончания учебы, сертификация, стандарты, последипломное образование.