The Usage of Robotics as an Element of STEM Education in the Educational Process

Alina Rakhmanina[1†], Iryna Pinchuk[2††], Olha Vyshnyk[3†††], Olena Tryfonova[4††††],
Tetyana Koycheva[5†††††], Viktor Sydorko[6††††††], Olena Ilienko[7†††††††]

[1†] PhD Student, Department of Pedagogy, National University of Life and Environmental Sciences of Ukraine, Ukraine

[2††] Doctor of Pedagogical Sciences, Assistant Professor, Head of Department of Theory and Methods of Primary Education, Oleksandr Dovzhenko Hlukhiv National Pedagogical University, Ukraine

[3†††] Candidate of Pedagogical Sciences, Department of Theory and Methods of Primary Education, Oleksandr Dovzhenko Hlukhiv National Pedagogical University, Ukraine

[4††††] Doctor of Pedagogical Sciences, Department of Natural Sciences, Chemistry, Geography and their Teaching Methods, Volodymyr Vynnychenko Central Ukrainian State Pedagogical University, Ukraine

[5†††††] Doctor of Pedagogical Sciences, Full Professor, Department of Pedagogy, State Institution "South Ukrainian National Pedagogical University named after K. D. Ushynsky", Ukraine

[6††††††] Deputy Director for Academic Affairs, Teacher-Methodologist, Detached Subdivision "Boyarka Professional College of National University of Life and Environmental Sciences of Ukraine", Ukraine

[7†††††††] Doctor of Sciences in Pedagogy, Associate Professor, Head of the Department of Foreign Languages, O.M. Beketov National University of Urban Economy in Kharkiv, Ukraine

Summary

The article highlights the importance of taking into account the need for cross-cutting knowledge and skills that can be applied in practice at the present stage of development of educational space. It is determined that the spread of knowledge that is useful in practice, creates the need for STEM-technologies (learning in practice) in the education system. The concept of STEM education is outlined – a combination of natural sciences, technology and engineering with mathematical, accurate calculations. That is why the analysis of the development of modern society, and especially the latest information technologies, shows the popularization of science and technology, in particular – robotics. In addition, it is determined that one of the most promising areas of STEM education today is educational robotics, the introduction of which is appropriate at all educational levels, starting from primary school. The use of robotics elements in primary school, which allow to diversify the educational process through the introduction of games and practical activities, is characterized.The concept of "robotics" is also characterized as interdisciplinary, which allows the use of interdisciplinary links in the educational process of primary school.

Keywords: STEM education, robotics, latest information technologies, educational process, primary school.

1. Introduction

We live in a rapidly evolving world driven by creativity, innovation and knowledge. The cornerstone of acquiring good knowledge, showing creativity and transforming knowledge into innovation is education [22].

The spread of the popularity of the use of robotics in the educational process, at the present stage of development of science and technology, indicates the expansion of the use of robots. Analysis of world trends has shown that robotics is one of the leading educational areas. It follows that educational robotics is one of the promising areas of STEM education. Therefore, it can be argued that the introduction of elements of robotics is appropriate at all levels of education, including primary school. Since the use of robotics allows you to use in the educational process elements of the game, which is most acceptable for the development of motivation to learn and the cognitive sphere of primary school students [22].

At the present stage of development of educational space, the educational potential of robotics is extremely large, as there is already an urgent need for specialists to develop, design and program robots. Thus, the involvement of young students in the study of robotics is extremely important for the further development of technology in our country, and, consequently, the relevance of the introduction of educational robotics in schools is unquestionable. In addition, learning with the help of robotics gives students the opportunity to solve real life problems that require knowledge of STEM subjects [25].

STEM education is a series or series of courses or programs that prepares students for successful employment, after-school education, or both, and requires a variety of more technically complex skills, including mathematical knowledge and scientific concepts. STEM (S – Science, T – Technology, E – Engineering, M – Mathematics). The acronym STEM is used to denote a popular field of education that encompasses science, technology, engineering, and mathematics. This is an area of education in which the curriculum enhances the science component + innovative technologies [23].

2. Analysis of recent research and publications

Strutynska O. substantiates the importance of relevance and timeliness of the introduction of educational robotics in the educational process of schools. To solve the research problems, the current state of development of robotics as an applied industry and as an educational trend is analyzed. Analysis of global trends in the development of robotics as an applied industry has shown that robotics is one of the branches of science and technology that is currently developing rapidly. This leads to the conclusion that it is necessary to train relevant specialists, which, in turn, leads to the need to update the content of school and university education in accordance with current requirements [25].

Davydenko Yu. Describes the process of implementing STEM education in primary school. The author argues that in order to prepare the younger generation for life in a high-tech competitive world, it is necessary to develop interest in scientific and technical creativity, technology and high technology. On the path of intensive development today, education requires a significant number of experienced specialists in the field of innovation, which will be the key to successful development and competitiveness of our country in the near future [3].

Kuzminskyi A.I., Bida O.A., Kuchai O.V., Yezhova O.V., Kuchai T.P. conducted research on the status of information support of educationalists made it possible to install that such basic functions of scientific and pedagogical information as analytical-prognostic, integrative, and a function of operational and purposefull formation of various categories of specialists at present are not sufficiently implemented. This can be accounted for by the versatility and complexity of pedagogical process itself, as well as by a low level and limited range of developing operational systems differentiated scientific and methodological services to various categories of teaching staff. The research classified the types of information required in the system of postgraduate education of teaching staff

Based on the theoretical analysis of information access in the system of postgraduate pedagogical education (PPE), and programs of information and library service of teaching staff, it has been rationalized that there is a great necessity for establishing centers of scientific and information support aiming at improving the qualification of teaching staff. With this in view, ways of improving the informational function ofPPE have been thoroughly studied and revealed. The most significant of them suggests that an automated corporate information system and a corresponding Internet site must be created. This can ensure the remote search and delivery of electronic materials from the funds of the State scientific and pedagogical library, and the libraries of educational institutions; an exchange of resources with other libraries and organizations; developing information and telecommunication technologies in institutions of postgraduate education; training teachers to use computer technologies, etc [9].

Semenikhina O.V., Yurchenko A.O., Sbrueva A.A., Kuzminsky A.I., Kuchay O.V., Bida O.A. describe the results of quantitative analysis of open educational resources in the field of information technology. The study is based on a study of the content of ten platforms that provide access to open PR. Researchers analyzed and summarized Internet sources to determine the popularity of educational platforms and resources on them. Quantitative data analysis was performed to determine the relative share of IT courses by various parameters: the relative share of IT courses in general and on each platform in particular, the language of instruction, quantitative content by thematic areas. Quantitative analysis was conducted for individual platforms where access to open educational resources is provided: Coursera, Edx, Udemy, MIT OpenCourseWare, OpenLearn, Intuit, Prometheus, UoPeople, OpenLearningInitiative, Maidan Open University (VUM). These platforms and general characteristics of their content are briefly described. According to the analysis of course titles and annotations to them, 10 generalized thematic areas are identified, which are offered by platforms for the IT industry: programming and software development; algorithms and data structures; computer security and networks; computer graphics, data design and visualization; Web-design and Internet technologies; DBMS and SQL; artificial intelligence and robotics; blockchain and cryptography; Operating Systems. The popularity of programming and software development courses and courses in computer graphics, design and data visualization have been proven. The general characteristics of the Ukrainian platforms Prometheus and VUM are given. The conclusion about the prospects of their development is formulated. Among the well-known educational platforms, the most filled with various courses are foreign Coursera, EdX, MIT OpenCourseWare, OpenLean and Intuit. The leadership positions of the Udemy resource are obvious in terms of the number of courses in total – 82943 and the number of IT courses – 35727. Suggestions for improving the training of IT professionals: organization of independent work courses and promoting them on open platforms [20].

In his research, O.V. Kuchai highlights the problem of the role of multimedia education in the formation of the information society. Reveals the world experience of multimedia technologies and the formation of information culture of the future teacher. Characterizes the positive and negative aspects of the use of multimedia technologies in primary school [7].

In addition, on the basis of a broad analysis of scientific and pedagogical sources and modern periodicals Kuchay O.V. analyzed the problem of multimedia technologies in the training of primary school teachers. The role of the latest technologies in the training of highly qualified specialists in

the pedagogical field is revealed. Possibilities of using cloud technologies in the professional activity of primary school teachers are outlined. Emphasis is placed on the possibilities of using Google Glass in education. The manual is intended for students of pedagogical faculties who can use it when studying the course "comparative pedagogy", as well as for all who are interested in the problems of comparative pedagogy [8; 10].

Kuchai O., Yakovenko S., Zorochkina T., Okolnycha T., Demchenko I., & Kuchai T. The article considers the training of specialists in education in the conditions of distance learning. It is lights up the advantages of distance learning and determined the characteristic features of distance learning of students training in the implementation of these technologies in the educational process.

The article focuses on the main aspects of computerization of studies as a technological breach in methodology, organization and practical realization of educational process and informative culture of a teacher. Information technologies are intensive involved in life of humanity, educational process of schools and higher educational establishments. Intercommunication is examined between the processes of informatization of the society and education [6].

Bida O., Prokhorchuk O., Fedyaeva V., Radul O., Yakimenko P., & Shevchenko O. In the spring, 2020, the pandemic caused quarantine and all educational institutions switched to distance learning, which led to significant changes in the field of education around the world. It has become necessary to build its capacity to provide distance learning to protect education and create opportunities for more individualized approaches to teaching and learning not only during future pandemics but also during other possible issues, such as natural disasters, when a developed flexible curricula could be taught face-to-face or online. The article presents an analysis of distance education in the world during a pandemic, analyzes significant changes, and implements measures in the field of education in Ukraine and around the world. The role of public and international organizations in the implementation of quarantine in the conditions of COVID-19, which partially took over the functions of state and local authorities, is emphasized. The closure of schools under COVID-19 has led to a de facto deterioration in learning outcomes, so we have analyzed the effects of distance learning and digital inequality in the world. It is shown how the COVID-19 pandemic affected access to public services in Ukraine [2].

The aim of the article. Characteristics of features and benefits of the introduction of elements of robotics as an element of STEM education in primary school.

3. Research methods

To solve this problem, a set of additional research methods was used: system-logical, analysis, systematization and generalization, materials for formulating conclusions, recommendations and ways to further develop the implementation of STEM education in primary school.

4. Results

In order to create conditions in Ukraine for balanced harmonious formation of science-oriented education based on modernization of mathematical and natural sciences and humanities profiles, popularization of engineering professions among students, raising awareness of their career opportunities in the technical field, forming a strategic approach to choose a future profession [19].

Currently, teachers are working in a new model of education, the implementation of the concept of "New Ukrainian School", the introduction of new approaches, in particular, STEM education. STEM education is relevant and necessary in a real fast-changing world, where you need to be able to respond to change, think critically, be a creative person. In the system of general secondary education there are 3 stages of STEM implementation: primary school, secondary school, high school. When it comes to primary school, it is the formation of research skills, but, of course, in a form accessible to a certain age, mental and mental development; laying the foundations of awareness of STEM-industries and professions; stimulating students' interest in further STEM-related courses [12].

In primary school, the main emphasis can be on LEGO-creativity and LEGO-design. To do this, use LEGO kits of various configurations and training set «First Robot WEDO». In addition to designing, students are introduced to the simplest robot programming environment, "breathing life" into the created models. In addition, early involvement in STEM can support not only the development of creative thinking and the formation of the researcher's competence, but also contribute to better socialization of the individual [3].

The use of LEGO-models and robots in the educational process of primary school involves the use of elements of educational robotics.

Robotics is a relatively new scientific field, which is developing rapidly, due to the need to develop new areas and branches of human activity, as well as the need for broad automation of modern production aimed at sharply increasing its efficiency, design, operation and use of robots [1; 25].

One of the tools for the implementation of STEM education is educational robotics, which takes a modern approach to the introduction of elements of technical

creativity in the educational process through the combination of design and programming. Robotics, as an applied science, is based on such disciplines as electronics, mechanics, programming. Accordingly, in school robotics can be integrated with such subjects as mathematics, physics, computer science. In the primary grades of secondary schools, robotics is well correlated with the goals and objectives solved by the educational program of primary school [27].

Educational robotics, in general, is a method of teaching where robots are used by students, usually under the guidance of a teacher [14].

The basic concept in robotics is "robot", which means an automated technical system or intelligent machine that mimics human actions and activities. Depending on the parameters of production, robots are divided into two classes: manipulation and mobile work. Manipulation works – automatic machines (stationary or mobile), consisting of an actuator in the form of a manipulator with several degrees of mobility, and software control devices. Mobile works – automatic machines that have a movable chassis with automatically controlled drives [1].

One of the areas of implementation of robotics as an element of STEM education is the educational concept of LEGO Education.

The LEGO Education concept identifies 4 components of learning – networking, design, reflection and development. First, students get acquainted with the device to be studied. Next, they build this mechanism using design elements and assembly diagrams. At the next stage, students study the built mechanism, experiment, conduct research, draw conclusions, note the test results. The final stage is an attempt to improve the mechanism created, to apply it to the environment. In working with students, it is advisable to combine them into groups of two. The next designer is "Robotics. WeDo 2.0" includes 16 thematic projects related to the environment, its protection, wildlife and more. Students have the opportunity not only to design a robot that must solve a problem, but also to program it using an intuitive visual programming environment. Along with LEGO Education, several educational robotics companies have emerged and introduced a number of robotics training solutions to the education market [15].

LEGO Education allows you to create a motivating, exciting educational environment not only for learning key subjects of the school curriculum, but also for the development of key skills of the XXI century: critical and creative thinking, problem solving, teamwork, discussion, finding a common solution in a controversial situation [5].

For primary school students, it is advisable to use WeDo 2.0 kits to develop critical thinking, spatial imagination, basics of computer science and programming. Elementary students have the opportunity not only to design models according to the instructions, but also independently, by posing problems and finding ways to solve them, to create

their own projects. In addition, students learn the basics of programming, learn to create controlled and autonomous models from the WeDo 2.0 constructor.

Robotic educational platform WeDo 2.0 was created to develop primary school students' skills in research activities. The bundled computer and tablet software offers an easy-to-learn programming environment and includes the WeDo 2.0 Learning Project Kit with assignments in science such as basics of biology, physics, technology, geography and astronomy [4].

An important point in using WeDo 2.0 is documentation. This is one of the most important innovations, which encourages students to constantly record their ideas, designs, projects, make a work plan and monitor at each stage the result [5].

The language of Wedo 2.0 is clear, so it makes learning the material as easy as possible (implementation of the principle of accessibility). WeDo 2.0 is methodically created according to the requirements and principles corresponding to those that should be used in primary school [11].

LEGO Education programs are designed for all elementary school subjects. In mathematics classes LEGO is used to consolidate and develop the skills of direct and counting, comparing numbers, knowledge of the composition of numbers, geometric figures; ability to navigate the plane, the ability to classify by features; can be used as a conditional measure when comparing objects in length, width, weight. You can also use the constructor in language classes. Yes, men in colorful suits, which are in sets, can depict vowels and consonants. Working with LEGO, children prepare for writing and reading, learn to formulate their thoughts. In science classes, LEGO is used in experimental activities as a material from which the designer is made [5].

The introduction of LEGO Education in the educational process promotes the integration of subjects, that is robotics and LEGO-design have become tools for the introduction of STEM education, which involves solving one of the educational problems – the transition from knowledge to education paradigm [28].

Through active, exciting activities, LEGO Education solutions for primary school develop the skills necessary for successful development throughout life. Practically-oriented solutions awaken in children a natural desire for research and discovery. Thanks to the use of LEGO Education kits, students learn languages and mathematics more effectively, and study literature and the world around them with enthusiasm [5].

For grades 3-4 there is an interesting solution from Little Bits Electronics – Little Bits STEAM. Small electronic components for various purposes, which are combined with magnetic connections, allow students to create interesting electronic systems and apply them in project activities. Alarm for the portfolio, automatic feeder for pets, robotic

systems – many interesting projects are presented by the company on the educational portal and in the methodological materials that come with the designer. The creative combination of this tool with other educational designers provides ample opportunities for learning robotics, starting from primary school age [15].

One of the other advantages of introducing robotics into the educational process in primary school is computational thinking, which forms in students a sequence of actions related to technology.

The world is changing, and whether we notice it or not, technology and computer science affect almost every aspect of our lives. Children are fast becoming active citizens, so the development of the necessary set of skills is currently one of the priorities of the state. Computational thinking is a group of skills that is rapidly spreading around the world and forming a key way of dealing with technology. Computational thinking and similar competencies are firmly established in many other state educational standards around the world. These important skills can be developed through project activities based on real life situations [4].

As you know, in elementary school, learning the basics of creating robotic designers occurs during the study of computer science, mathematics, natural sciences, as well as a special course in elective classes. In the conditions of additional education acquaintance with the basics of robotics is carried out during educational experiments in related fields of knowledge – physics, electronics, mechatronics, automation, biology, chemistry. Involving students in the process of programming and designing robots establishes interdisciplinary links between computer science, mathematics and physics, cyber physiology and psychology, mechatronics and technical design, and thus integrates knowledge in different fields of science. In this process, robotics acts as an integrator of the system integrity of the acquired knowledge. Thus, the educational space expands into new areas of knowledge, identifying promising vectors of its development. In the modern educational space, the training of scientific, technical and engineering personnel for innovation is carried out as a continuous process, organized on the principle of continuity in the system "kindergarten – school – university". A special place in this process belongs to the primary school, where propaedeutic work is carried out on career guidance of students in the field of artificial intelligence and robotics, their involvement in scientific and technical creativity. With the help of robot programming, the younger student can provide intelligence to their models, including devices used in the home and powered by electricity, mobile work with a temperature sensor and a sensor for measuring the magnetic field. More difficult tasks are set for students in the process of working with sets of Lego Mindstorms EV3. The abbreviation EV3 stands for Evolution 3 [17].

The robots of the new generation walk, ride, talk, think. The functionality of the robot depends on the imagination and fantasy of the student [21].

In the context of updating the content of education, robotics occupies an increasingly important place in the process. The basis of robotics is a practical and productive focus of knowledge, which allows to create conditions for self-expression and success of students, the realization of their creative potential. At present, society needs a person who is able to independently set educational goals, design ways to implement them, monitor and evaluate their achievements, work with different sources of information, evaluate them and on this basis to formulate their own opinions, judgments, assessments. Robotics meets these requirements. Robotics is a field of technology related to the development and application of robots, as well as computer systems for their control, sensory feedback and information processing. Today, robotic designers are used to conduct demonstration training experiments in physics, chemistry, biology, mathematics and basics of life safety. All this allows to acquaint the child with the laws of the real world and the peculiarities of the functioning of perception of this world by cybernetic mechanisms [18].

In primary school educational robotics can be successfully used in lessons of the world, mathematics, technology, which will provide a significant impact on the development of students' language and cognitive processes (sensory development, development of thinking, attention, memory, imagination) and emotional sphere and creative abilities [27].

The main purpose and objectives of the introduction of educational robotics in the educational process of educational institutions are: the formation and development of students' interest in natural and exact sciences, scientific and technical creativity, which corresponds to the ideas of STEAM-education; formation of students' skills in working with technical devices and skills of practical solution of current engineering problems; formation of skills to work with different data sources, evaluate them and, on this basis, formulate their own opinions, judgments, assessments; initiate and create your own developments; intellectual development of personality, in particular the development of logical, algorithmic and creative thinking, memory, attention, scientific intuition; formation of the scientific worldview as an integral part of the general culture of man, a necessary condition for a full life in modern society; formation of cross-industry competencies (knowledge at the intersection of different subjects, industries, skills and abilities to apply them in real practical situations); formation of soft skills (soft skills), including interpersonal skills, ability to work in a team, responsibility, problem-solving strategies; formation of personality qualities that are able to independently set goals, design ways to implement them, monitor and evaluate their achievements; formation and development of sustainable motivation to learn [25].

One of the ways to motivate primary school students to study is the competition, which includes the family STEM festival ROBOTICA – a festival of educational innovations and modern technologies in education. And it's just a great way to spend a weekend with family and get to know the world of robotics and engineering. A feature of the festival is the National Selection for the World Robot Olympiad (WRO - World Robot Olympiad). This is one of the most important events for young robotics professionals from all over the country. Thousands of children design robots in accordance with the tasks of the Olympiad and compete for the right to represent Ukraine at the WRO [24].

Holding festivals and competitions in robotics is an additional incentive for primary school students, and in addition to developing skills in areas such as mathematics, computer science, science, engineering, students are able to develop a sense of team spirit, learn to work in a team and with a partner. in turn, it is an integral skill in real life, in contrast to theoretical knowledge without their application in practice.

The World Robot Olympiad (WRO) is one of the largest in the world. This is a key event in the field of the latest educational technologies and educational programs. Robotics is a great platform for acquiring the skills needed in the 21st century. Solving robotic problems gives rise to innovation, creativity and problem-solving skills. This will later be reflected in the applied fields of science, engineering and computer programming. During the tasks, young people work in a team, they learn together in an exciting way, so the process of cognition is as natural as breathing itself [24].

Therefore, the introduction of educational robotics in primary school is appropriate not only in the lessons, but also in extracurricular activities related to the educational process.

Educational robotics is a tool that provides a significant impact on the development of students' language and cognitive processes (sensory development, development of thinking, attention, memory, imagination), as well as the emotional sphere and creativity. Educational robotics allows you to create dynamic schemes in the classroom, reflecting certain phenomena, to make the demonstration of experiments bright, colorful and more visual. Educational robotics allows to increase the number of practical works, demonstrations and generalization lessons [13].

The use of educational robotics makes it possible in the early stages to identify the technical inclinations of students and develop them in this direction and the direction of formation of STEM competencies in general [16].

Conclusions

Thus, we can conclude that in the conditions of development of modern educational space, in primary school the most relevant progressive direction is STEM education. In turn, robotics is the most promising part of STEM education, as it covers various fields of knowledge (mathematics, language, technology, engineering). The use of elements of robotics in primary school allows students to identify and develop abilities in technical professions, in addition, to develop skills of critical thinking, problem-solving analysis, which is an integral part of real life and allows to apply acquired competencies in practice. only in theory. The above characteristics of the field of robotics in primary school, suggest that this area has enough advantages to be called a promising educational field in modern technologically advanced society.

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