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Advancing educational robotics: competence development for pre-service computer science teachers

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Abstract. The rapid growth of robotics as an applied industry has created a pressing demand for robotics specialists skilled in the development, design, and programming of robots. This has led to the widespread popularity of robotics as an educational trend, both in Ukraine and worldwide. Integrating educational robotics into STEAM education offers a powerful platform for cultivating students' soft skills, enabling them to tackle real-world socially significant projects and bridging the gap between theoretical knowledge and practical application. Consequently, there is a crucial need to equip pre-service teachers with the necessary skills to effectively teach educational robotics to students. This article addresses the issue of establishing a comprehensive model of competences in educational robotics for teachers and explores strategies for their development. The research demonstrates that pre-service computer science teachers exhibit the highest readiness to teach educational robotics in secondary schools. The article focuses on developing and validating a model of competences in educational robotics for pre-service computer science teachers, highlighting its effectiveness through the teaching of educational robotics disciplines. By fostering competence development among teachers, this study aims to advance the integration of educational robotics in classrooms, empowering students to thrive in a digitally-driven society.

Keywords: robotics, educational robotics, competence development, pre-service teachers, STEAM education, computer science teachers

1. Introduction

The current stage of science-and-technology development is characterized by the growing popularity of robotics and increasing the use of robots. Analysis of global trends in the robotics industry shows [27]:

- Growth in the production of industrial, service and domestic robots. According to *International Federation of Robotics (IFR)*, stock of industrial robots increased by 12% (about 2.7 million units) in 2019. Sales of service and domestic robots increased by 34% in 2019 and by 15% in 2020 [11];

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- Accelerated growth of industrial robot production in the period from 2019 to 2021 (according to IFR estimates, the rate will accelerate to 14% on average per year);
- Introduction of robotic mechanisms and complex automation of production in many areas of social activity (industry, military, space, automotive, aviation, medicine, services, domestic life, etc.);
- Development of so-called ***Smart Factories*** as one of the components of the ***Industry 4.0*** concept, the main idea of which is the development and integration of automated production, data exchange and production technologies into a single self-regulating system with minimal or no human intervention in the production process. ***Smart Factory*** is a factory where the equipment is automated and controlled by a computer. The equipment can receive feedback on the state of the object in physical space using sensors;
- Acceleration of production automation (according to research by the World Economic Forum (WEF), the ratio in the division of labor "human-robot" will be significantly changed (by 2025) towards robotics – up to 52%;
- Increasing the interest of the world's largest companies in robotic startups. In particular, in early 2014, Google has acquired eight companies engaged in intelligent robotics;
- Growing demand for specialists in the robotics industry in general, as there is already an urgent need for specialists to develop, design and program robots.

As of today, industrial robots and integrated automation of production are in demand in many areas of social activity [17]:

- *Industry* (robots for painting, welding robots, robots for cutting metal, etc.);
- *Agriculture* (agricultural robots for harvesting and picking, weed control);
- *Military industry* (military robots, intelligence robots);
- *Medicine* (microscopic robots for use in microsurgery, robots-couriers in hospitals);
- *Aircraft* (unpiloted robots-airplanes);
- *Space industry* (self-propelled vehicles based on robotic systems);
- *Service sector* (robots for help people with special needs);
- *Domestic life* (robots-vacuum cleaners).

Especially robotics play important role for agricultural needs. It is quickly becoming an exciting high-tech industry, drawing new professionals, new companies and new investors. The technology is developing rapidly, not only advancing the production capabilities of farmers but also advancing robotics and automation technology. Robots pick apples, gather strawberries, harvest lettuce and strip away weeds. Drones gather aerial images that help farmers quickly assess crop health. And robotic greenhouses are sprouting up thousands of miles away from traditional farmland regions, growing vegetables in the backyards of high-consumption urban markets. It all comes at a time when growers face a costly, long-term labor shortage and — with the global population expected to rise from 7.7 billion to 9.7 billion in just over 30 years — food demand is poised to rise significantly [9].

Robots change the way we live and work. This also means that there is already an urgent need for specialists to design, construct and program robots.

Thus, the above shows the rapid development of robotics, which in turn causes the need in appropriate training of qualified professionals for this field. This contributes to the popularity of robotics as an educational trend in Ukraine and in the world.

Paper goals are: to characterize educational robotics as a trend of STEAM education; to develop a model of competences in educational robotics for teachers; to identify ways to develop competences in educational robotics for pre-service computer science teachers.

2. Educational robotics as part of STEAM education

STEM education is becoming one of the most important educational trends among educators in Ukraine. This is confirmed by Hrynevych et al. [10], Martyniuk et al. [13], Mintii [15], Morze, Smyrnova-Trybulska and Gladun [16], Morze, Vember and Gladun [19], Strutynska and Umryk [29].

STEM education (**S**cience, **T**echnology, **E**ngineering, **M**athematics) is a trend in education, under the conditions of which the science component (with the use of innovative technologies) is strengthened in the curricula.

The importance of involving young people in STEM training is also shown by a research conducted in the EU in 2018 at the initiative of the World Economic Forum under the *Digital Transformation Initiative*. The research identifies seven key technologies that are projected to have the greatest impact on industrial transformation in the near future [5] (figure 1):

- *Artificial Intelligence*;
- *Autonomous Vehicles*;
- *Big Data Analytics and Cloud*;
- *Custom Manufacturing and 3D Printing*;
- *IoT – Internet of Things / Connected Devices*;
- *Robots and Drones*;
- *Social Media and Platforms.*

All these technologies are related to digital competence, technical competence and STEM. It should also be noted that 3 of the 7 above technologies are directly related to robotics, namely: *Autonomous Vehicles, Internet of Things and Connected Devices, Robots and Drones* (figure 1).

This indicates that the demand for specialists in STEM professions will continue to grow, including workers in the robotics industry. To implement this, a high-quality STEM subject training is needed (mathematics, physics, technology, engineering, programming, etc.).

However, in many parts of Europe, employers have difficulty recruiting people with the right level of STEM skills, especially IT professionals. In addition, the latest PISA (*Program for International Student Assessment*) data show that one in five 15-year-olds in Europe is functionally illiterate in reading, math and science [14, 29].

One of the possible ways to involve young people in STEM subjects is to add to the exact sciences the so-called component of *Art*. Therefore, recently STEM education includes disciplines related to creativity and art, united by the general term ***Arts*** (***STEAM*** – STEM and Arts) [30].

According to Edel [6], an attempt to intensify education only in the direction of science without the parallel development of Arts-disciplines may lead to the fact that the younger generation will lose the skills of creativity. For example, Massachusetts has passed legislation that takes into account not only the level of students' performance of standardized tests, but also the extent to which each school's curriculum enhances student creativity, the so-called "*creativity index*".

Robotics is one of the promising areas of modern STEAM education [18]. Educational process with robotics provides students with the opportunity to solve real life problems that require knowledge of STEAM disciplines, in particular [17]:

- *mathematics* (spatial concepts, geometry for understanding the methods of robot movement);
- *physics* (electronics, principles of sensors operation that constitutes the basis of robots);
- *technology and design* (design of devices, parts of robots, their design);
- *ICT* (programming of robotics systems).

Nowadays, increased attention is paid to robotics as to applied science, including its educational and developmental potential. This has created a new trend in education: *educational robotics.*

Educational robotics is a crossdisciplinary area of students' learning. Its process integrates the knowledge of STEM subjects (physics, technology, mathematics), cybernetics, mechatronics, and informatics. Teaching educational robotics corresponds to the ideas of advanced training (learning the technologies that will be needed in the future) and allows students of all ages to be involved in the process of innovation, or scientific and technical creativity [17].

In Ukraine, the development of educational robotics within the educational process occurs at the concept level, in the teaching of computer science and ICT, in extracurricular education, but for this time there is no systematic approach. Therefore, the issues of importance are the introduction of robotics in the educational process of secondary and higher education as one of the areas of STEAM education, development of appropriate curricula for students, training of pre-service teachers who will teach educational robotics, development of relevant competences in educational robotics [18, 27].

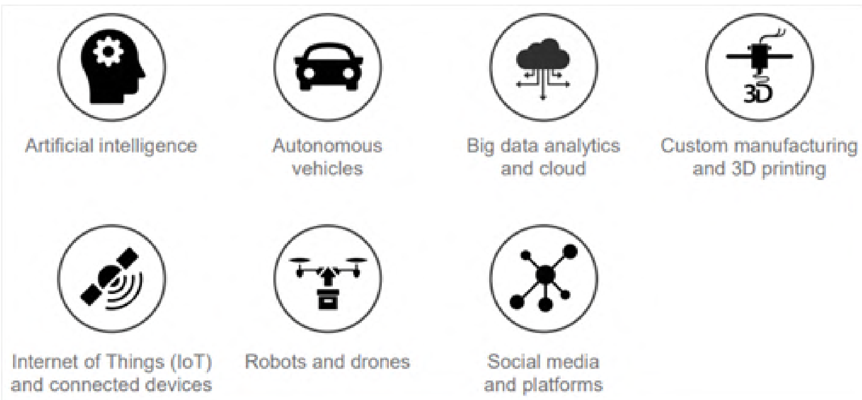

Figure 1: Technologies that transform the industry in the near future [5].

3. Competences in educational robotics for teachers

3.1. Components of the competences in educational robotics

Preparing of today's youth to the design, programming and use of robots and robotic systems is associated with the requirements of today, namely the emergence of new professions in the field of robotics and, consequently, the need for appropriate specialists:

- operator of multifunctional robotic systems;
- robot designer (in particular designers of industrial and children's robotics, medical and home robots);
- designer of neuro-interfaces for robot management;
- designer of "smart" houses;
- unmanned aerial interface designer;
- service engineer in robotics;
- robotics programmer;
- medical robot operator;
- drone operator;
- drone engineer;
- teacher of robotics;
- builder of "smart" roads, etc.

Taking into account that robotics already plays an important role in various areas of social activity and that its role will increase in the future, it is necessary to prepare the current generation of students for this. This needs updating the content of school and university education in accordance with today's requirements. Therefore, today the issues of introduction of robotics in the educational process of higher education institutions (as a mandatory component of training pre-service teachers) are of particular importance.

The same opinion is shared by Anisimova, Sabirova and Shatunova [1]: "...the key discipline in the content of training teachers for STEAM education should be "Educational Robotics". Kushnir et al. [12] note that "...introducing the Educational Robotics course for future teachers is an important part of their professional training".

Thus, the development of pre-service teachers' competences in educational robotics is a topical issue of today.

Competence approach plays a special role in higher education while the training of qualified specialists. Its use makes it possible to update the content of education and ensure that education meets the needs of modern economy and civilization.

Below are the most important studies devoted to the question of determining the components of competencies in robotics, including education, their structures and models.

Eguchi [7] notes that the teaching of educational robotics contributes to the formation of pupils and students of the so-called 21 Century Skill (21 Century Skill Framework [2]), which include:

- Core Subjects (English, World languages, Arts, Mathematics, Economics, Science, Geography, History);

- 21st Century Themes (global awareness; financial, economic, business and entrepreneurial literacy; civic literacy; health literacy);
- Learning and Innovation Skills (creativity and innovation skills, critical thinking and problem solving, communication and collaboration skills);
- Information, Media and Technology Skills (information literacy, media literacy, ICT);
- Life and Career Skills (flexibility and adaptability, initiative and self-direction, social and cross-cultural skills, productivity and accountability, leadership and responsibility).

Goloborodko [8] considers robotics as a resource for the formation of key competencies, namely information, communication, educational and cognitive and competence in the field of health. Kushnir et al. [12] also note that "robotics helps build core competencies. This affects the formation of a scientific worldview and the corresponding system of thinking".

Morze, Gladun and Dziuba [18] indicate that robotics classes affect the development of students' mathematical, scientific and technical competences, computer science competences, as well as social competences.

Buzhinskaya, Grebneva and B. [4] define a set of competences needed for the successful application of robotics in the future professional activity of students. The most important of them (in the researchers' opinion) are development of programs for robotics management, mastery of methods of testing and debugging programs for robotics management, methods of assessing the quality of robotics management programs, etc.

In 2014–2015, a research project "Remake Learning Competencies" involve more than 100 experts in various subjects, teachers of formal and non-formal learning and program managers [24]. In the course of the research, seven working groups were created to develop different competency structures, as well as to identify cross-cutting competencies (*Cross-Cutting Competencies*).

As part of the "Remake Learning Competencies" project, a group of researchers proposed seven competency structures: *Career Readiness, Coding & Gaming, Design & Making, Media Making, Robotics, STEAM and Early Childhood Education.* Each of the developed structures consists of *knowledge, skills and abilities.*

The structure of competences in the field of robotics (proposed by the project) includes [24]:

- *knowledge in Robotics* (Circuits, Design Process, Materials & Their Characteristics, Programming Languages, Systems Thinking);
- *skills in Robotics* (Circuit Board Construction, Communication, Designing for Human-Robot Interaction, Engineering, Ethics, Fabricating, Programming);
- *dispositions in Robotics* (Collaboration).

Analysis of researches devoted to the definition and formation of competences in educational robotics shows that today there are no common approaches to developing a model of competences in educational robotics, in particular for teachers. Thus, the solution to this issue is relevant and open to research.

Analyzing the components of the above structures and models of competences in educational robotics, it should be noted that they include *components of STEAM competences.* Their inclusion in the structure of competences in educational robotics is logical, because educational robotics is a trend which integrates knowledge of many disciplines, including computer science, environmental science, mathematics, technology and others.

One of the characteristic features of educational robotics is learning through project activities. While working on robotic projects, students perform research according to the task. Thus, taking into account also the fact that research activity is a characteristic feature of STEAM subjects, *research competence* [21] will be one of the components of competences in educational robotics.

An important component of educational robotics training is programming, which is one of the main stages of a robotics project. In addition, the design stage of a robotic system is impossible without modeling of its components, which are often performed with the use of special software. These components belong to the *digital competence* [22, 23].

The formation of components of digital competence in the process of learning robotics is also mentioned in [25]. Buzhinskaya and Grebneva [3] describe the development of ICT competence of pre-service computer science teachers in the process of teaching robotics. Thus, the individual components of digital competence will be part of the competences in educational robotics.

Competences in educational robotics, in addition to knowledge, skills and abilities, include activity and / or value-motivational components, which include critical and creative thinking, the ability to work in a team, solving complex problems, etc. A significant number of these components are characteristics and personal traits that belong to soft skills. Thus, *soft skills* [26] are also parts of the competences in educational robotics.

Thus, based on the analysis of the above groups of competences, the authors identified the components of ***competences in educational robotics***, which include:

- integral STEAM competence (in the field of robotics);
- research competence;
- digital competence;
- soft skills.

3.2. Model of the competences in educational robotics for teachers

For successful teaching of educational robotics, it is necessary to develop appropriate competences in teachers who will be able to professionally and creatively prepare students for future professions related to the robotics industry. Thus, it is necessary to add a professional-and-pedagogical component (to the considered components of educational robotics), which will include knowledge of the laws, principles, methods of teaching-and-learning of educational robotics and the relevant skills and abilities. Such a component is *methodological competence* [20].

Thus, based on the analysis of the components and taking into account the above considerations, the authors developed a ***model of competencies in educational robotics for teachers*** (figure 2).

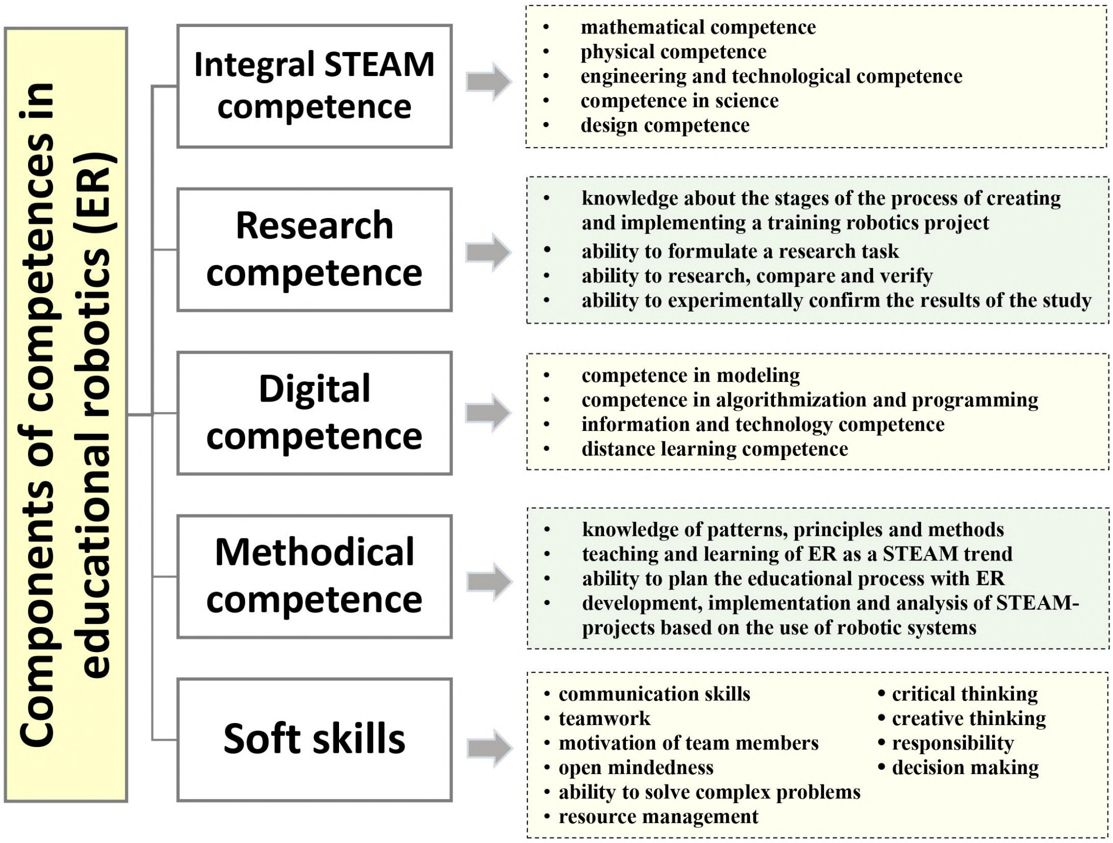

Figure 2: Model of competences in educational robotics for teachers

Table 1: Description of the components of competences in educational robotics (ER) for teachers.

ER competence	**ER competence components**	**Knowledge**	**Abilities and skills**	**Personal traits, ways of thinking**
Integral STEAM competence (in the field of robotics)	*Mathematical competence*	basic knowledge of fundamental mathematics sections; mathematical tools in the relevant field of knowledge	ability to use mathematical methods in the process of ER problem solving	algorithmic thinking, systematic thinking
Integral STEAM competence (in the field of robotics)	*Physical competence*	knowledge of microelectronics; understanding the principles of operation of simple mechanisms and mechanical transmissions	ability to work safely with electronic circuits, microcontrollers and robotic platforms in accordance with the project	responsible attitude to technology, understanding and compliance with safety measures when working with robotic platforms

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Table 1 – continued from previous page

ER competence	ER competence components	Knowledge	Abilities and skills	Personal traits, ways of thinking
Integral STEAM competence (in the field of robotics)	*Engineering and technological competence*	knowledge of the stages of the engineering design process at the level sufficient for the implementation of projects related to robotic systems	ability to design robotic systems	engineering thinking, technological literacy, systematic thinking
Integral STEAM competence (in the field of robotics)	*Competence in science*	basic knowledge of environmental sciences fundamental sections at the level sufficient for the implementation of projects related to robotic systems	ability to use knowledge of environmental sciences (including their interdisciplinary links) within the process of ER problem solving	
Integral STEAM competence (in the field of robotics)	*Design competence*	basic knowledge in the field of design at the level required for the design of robots and their parts	ability to create the design of robots and their parts, including using 3D technology	design thinking
Research competence		knowledge about the stages of the process of creating and implementing a training robotics project	ability to identify the problem; ability to formulate a research task and determine ways to solve it; activity planning; ability to research, compare, verify and experimentally confirm research results; system analysis, system evaluation	engineering thinking, the ability to solve problems in a non-standard way, understanding other points of view in solving problems; ability to apply knowledge in different situations
Digital competence	*Competence in modeling*	knowledge of methods of analysis, research and development of robotic systems models	ability to develop models of robotic systems; ability to adopt ICT for computer modeling of robotic systems	systematic thinking

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Table 1 – continued from previous page

ER competence	ER competence components	Knowledge	Abilities and skills	Personal traits, ways of thinking
Digital competence	*Competence in algorithmization and programming*	basic knowledge in the field of algorithmization; basic knowledge of one or more programming languages; features of their use for programming robots and robotic systems	ability to develop algorithms of robots and robotic systems, ability to program and test them	algorithmic thinking, systematic thinking
Digital competence	*Information technology competence*	knowledge of the characteristics of robotic platforms and the corresponding software; basic knowledge of the technologies operation principles based on the IoT	ability to select robotic platforms in accordance with the tasks, ability to work with emulators of robotic platforms; ability to use technologies based on the IoT to develop robotic systems	responsible attitude to technology, understanding and compliance with safety measures when working with robotic platforms and IoT
Digital competence	*Distance learning competence*	knowledge about the principles of functioning of online environments for robotics training, distance learning systems, video conferencing systems; knowledge of features (including psychological) concerning the organization of independent work of students in the conditions of distance learning	ability to work with online environments for robotics training; ability to organize the educational process using online environments; ability to design, create digital educational resources (including distance learning courses) with ER	understanding the principles of safe work in online environments; compliance with safety measures when working on the Internet, ethics; independence, motivation; psychological stability to work in distance learning

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Table 1 – continued from previous page

ER competence	ER competence components	Knowledge	Abilities and skills	Personal traits, ways of thinking
Methodical competence		knowledge of the principles of cognitive management; understanding the importance of the introduction of ER as a trend of STEAM education for the formation of students' scientific worldview; knowledge of patterns, principles, methods of teaching and learning of ER as a trend of STEAM	ability to plan the educational process with ER; development, implementation and analysis of STEAM projects based on the use of robotic systems; creation of learning environments and conditions for effective learning of ER, evaluation of ER learning outcomes	motivating students to learn ER
Soft skills			Communication and teamwork skills, solve complex problems, ability to make informed decisions, resource management	critical thinking, creative thinking, responsibility, motivation of team members, open mindedness, emotional intelligence

4. Preparation of the pre-service computer science teachers to teach of the educational robotics

Robotics is an effective means of engineering education for schoolchildren around the world. Therefore, the task of pedagogical universities is to train teachers to work with students in accordance with current trends, standards and requirements of today, including pre-service teachers who will teach educational robotics. In this regard, the following issues are becoming of high importance. Among these issues are: training students of pedagogical universities who will be able to teach children educational robotics, and, accordingly, the introduction of robotics in the educational process of higher education institutions as part of the training of pre-service teachers [28].

Summarizing the experience of practicing educators who teach educational robotics and research the preparation of pre-service teachers for its teaching, our previous research and experience, the authors believes that in the absence of a separate educational standard in Ukraine "Robotics", ***pre-service Computer Science teachers*** are the most ready to teach educational robotics in secondary schools.

Strutynska [28] substantiates in detail the feasibility of training pre-service teachers of computer science to teach educational robotics. Similar considerations are also shared by other researchers. For example, Vegner [31] believes that the most appropriate discipline for the training of specialists in the field of robotics is computer science. In his opinion, it is necessary to start training the future robotics engineer from the school time. However, this problem is rather difficult to solve within the traditional set of physical and mathematical disciplines.

Buzhinskaya and Grebneva [3] note that computer science is a leading discipline for teaching educational robotics. It should be taught by computer science teachers, respectively, as part of the school computer science course.

Zhaldak et al. [32, 33] developed the educational and professional training programs for bachelors and masters in the specialty 014.09 “Secondary education (Computer Science)” with a selective module of disciplines “Educational robotics” at the Faculty of Informatics of the National Pedagogical Dragomanov University. This is just to train pre-service computer science teachers, who will teach educational robotics. In the absence of a separate educational field “Robotics” according to the state standard of education, pre-service computer science teachers, who have chosen a selective unit of disciplines “Educational Robotics”, receive an additional qualification “head of the robotics club”.

Students of computer science specialties of pedagogical university study disciplines of the selective module “Educational Robotics”. These disciplines combine theoretical, applied and practical aspects of STEAM education. The main content lines of educational robotics are:

- *Basics of robotics*
- *Introduction to educational robotics*
- *Programming of robotic systems*
- *Physical basics of robotics*
- *Mathematical basics of robotics*
- *Methods of teaching educational robotics*

The experiment, which was conducted three academic years (2017–2020), involved 106 students who studied in the specialty 014.09 “Secondary education (Computer Science)”. During each subsequent academic year, changes were made to the structure and content of training disciplines in educational robotics (ER): 2017–2018 – 28 students (educational robotics training took place according to the content of modules of other disciplines – 16 students of the Bachelor program and 12 students of the Master program); 2018–2019 – 32 students (the training took place both in terms of modules of other disciplines (18 students of the Bachelor program) and in terms of the content of the selective block of disciplines “Educational Robotics” (14 students of the Master program)); 2019–2020 – 46 students (the educational robotics training took place within the framework of majors courses (23 students of the Bachelor program) and according to the content of the selective block of disciplines “Educational Robotics” (23 students of the Master program)). This selection of experimental groups was due to: a small number of students in groups who were trained in the relevant field of study; homogeneity of the conditions of the experiment (availability of hardware for educational robotics, the same number of hours for training relevant courses, and the same type of software and methodical support); and the dynamics of development of relevant technologies in the robotics industry.

Diagnostics of the levels of building of ER competences of pre-service teachers of computer science for each group was carried out in two stages: by assessing the levels of building of certain competence components at the beginning and after the formative stage of the experiment.

At the final stage of the experiment, there was a self-assessment of ER competences developed in the participants of the experiment. Besides that, the expert assessment of robotics projects (including STEAM and online projects) has been performed. It was done also with the participation of lecturers, practicing teachers, and leaders of educational robotics clubs (as experts). In some cases, mutual evaluation took place. Examination and evaluation of projects were carried out on the basis of the criteria developed by the authors of the study for assessing the final tasks and projects, as well as criteria for assessing the levels of competence components building.

The results of the experiment showed that the quality of training and the level of the building ER competence components of pre-service teachers of computer science increased owing to the proposed method (table 2).

Table 2
Students' percentage who have reached the stated levels of building of the relevant ER competence components.

ER competence components	Experiment stage	Competences' levels			
		low	basic	sufficient	high
Integral STEAM competence	at the beginning	22.64%	64.15%	11.32%	1.89%
Integral STEAM competence	at the end	8.49%	43.40%	34.91%	13.21%
Research competence	at the beginning	73.58%	23.58%	2.83%	0.00%
Research competence	at the end	35.85%	50.94%	10.38%	2.83%
Digital competence	at the beginning	28.30%	48.11%	21.70%	1.89%
Digital competence	at the end	9.43%	38.68%	33.96%	17.92%
Methodical competence	at the beginning	86.79%	11.32%	1.89%	0.00%
Methodical competence	at the end	16.04%	60.38%	16.04%	7.55%
Soft skills	at the beginning	31.13%	45.28%	15.09%	8.49%
Soft skills	at the end	19.81%	35.85%	29.25%	15.09%
General ER competences	at the beginning	48.49%	38.49%	10.57%	2.45%
General ER competences	at the end	17.92%	45.85%	24.91%	11.32%

Thus, according to the results of the experiment, there is an upward trend in development of ER competences of pre-service teachers of computer science, which confirms the effectiveness of teaching students according to the developed individual components of the methodical system. In particular, the number of students with basic, sufficient and high level of general ER competences has increased: with basic – increased by 7.36% (8 students); with sufficient – by 14.34% (15 students); with high – by 8.87% (9 students). At the same time, the number of students with a low level of these competences building decreased by 30.57% (32 students).

The experience of teaching students in the disciplines of the selective unit "Educational Robotics" showed the following. The training not only provides students with relevant knowledge of educational robotics (introduction to robotics, basic robotics models, design and construction programming of robotic platforms, environments for programming of robotic platforms, organization of tests of ready designs of robots (testing of robots, etc.), but also promotes formation in them of corresponding professional competences in educational robotics.

Besides, students have improved such key competencies as follows while studying:

- *Ability to learn (fast learning)*;

- *Civic competence*;
- *Social competence*;
- *Environmental literacy*;
- *Entrepreneurship.*

Areas of formation of competences in educational robotics for pre-service computer science teachers are:

1) formal training (relevant disciplines in educational robotics, provided by the educational program);
2) practical component of training (project activity of students);
3) non-formal learning (attending master classes by practicing teachers, robotics leaders, mentors and trainers, attending seminars, festivals, robotics competitions, self-education using MOOC, thematic groups and social media channels, etc.).

5. Conclusions

The introduction of educational robotics as a part of STEAM education is a powerful step for development of students' soft skills, training for the implementation of real socially significant projects, formation of practical value of theoretical knowledge, scientific world outlook and successful life in a digital society as a whole.

Based on the analysis of the world trends in the robotics industry and development of robotics as an educational trend, systematic analysis of scientific, methodological and the Internet sources regarding the research problem, generalization of these data, own experience and previous research (2015–2020), the conclusions are drawn about:

- growing demand for robotics specialists;
- increasing the popularity of robotics as an educational trend in Ukraine and around the world;
- urgency of training teachers to make them able to train future professionals in the field of robotics;
- relevance of the introduction of educational robotics in the educational process of higher education institutions as part of the training of pre-service teachers;
- importance of developing of the competences in educational robotics for teachers;
- effectiveness of the developed model of the Competences in educational robotics for teachers.

The practical experience of training pre-service teachers (who will teach of educational robotics) shows that pre-service computer science teachers are the readiest to teach educational robotics in secondary education. The research confirms the effectiveness of training pre-service computer science teachers for teaching educational robotics in secondary education institutions developed by educational and professional programs of the specialty 014.09 "Secondary education (Computer Science)" with a selective module of disciplines "Educational robotics".

Further research of the author will be aimed at identifying ways to develop educational robotics competences under the conditions of blended and distance learning.

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