

The background is a complex, abstract composition of white and light blue lines and shapes on a darker blue background. The lines are thin and vary in orientation, creating a sense of movement and connectivity. Some lines form circular or oval shapes, while others are straight and intersecting. There are also faint, semi-transparent text fragments scattered throughout, including words like 'Identity', 'Education', 'Learning', and 'Knowledge'.

**Didactic prototype of
student modern training:
aspect of educational
robotic complex realization**



Didactic prototype of student modern training: aspect of educational robotic complex realization

Prototipo didáctico de la formación moderna de los estudiantes: aspecto de la realización del complejo robótico educativo.

Igor O. Baklanov,

Doctor of Education, Associate Professor, Head of the Department of Physics and Chemistry, Military Educational Scientific Center of Air Force «Air Force Academy named after Professor N. E. Zhukovsky and Y. A. Gagarin», Voronezh, Russia.

E-mail: iobaklanov@yandex.ru

ORCID0000-0001-7093-6048

Olga A. Ruzakova,

Doctor in Law, Professor of the Department of Legal Regulation of Economic Activities, Financial University under the Government of the Russian Federation, Moscow, Russia. Doctor in Law, Professor of the Department of Civil Law Disciplines, Plekhanov Russian University of Economics, Moscow, Russia.

E-mail: Olalstep@mail.ru

ORCID0000-0002-7375-9427

Albina M. Fathutdinova,

PhD in Law, Associate Professor of the Department of Legal Regulation of Economic Activities, Financial University under the Government of the Russian Federation, Moscow, Russia.

E-mail: fam2510@mail.ru

ORCID0000-0002-9995-2911

Elena Yu. Matveeva,

PhD in Law, Associate Professor of the Department of Legal Regulation of Economic Activities, Financial University under the Government of the Russian Federation, Moscow, Russia.

E-mail: EYUMatveeva@fa.ru

ORCID 0000-0003-4166-8659

Natalya V. Grigoreva,

PhD in Law, Associate Professor of the Department of Legal Regulation of Economic Activities, Financial University under the Government of the Russian Federation, Moscow, Russia.

E-mail: navlagri@mail.ru

ORCID 0000-0002-4813-7802

Svetlana A. Savostyanova,

PhD in Law, Associate Professor of the Department of Legal Regulation of Economic Activities, Financial University under the Government of the Russian Federation, Moscow, Russia.

E-mail: sarudenko@inbox.ru

ORCID 0000-0001-5596-5166

Zaynab R. Khasmetova,

Deputy Dean of the Additional Education Faculty, North-Caucasian Institute (Branch), All-Russian State University of Justice (RPA of the Ministry of Justice of Russia), Makhachkala, Russia.

E-mail: ski_fdo@mail.ru

ORCID 0000-0002-6643-3488

Olga Yu. Senatorova,

PhD in Education, Associate Professor of the Department of Psychological and Pedagogical and Medical Support of Activity of Law-Enforcement Bodies, All-Russian Institute of Advanced Training of Employees of the Ministry of Internal Affairs of the Russian Federation, Moscow, Russia.

E-mail: pchela-fly@yandex.ru

ORCID 0000-0002-7096-146X

Fecha de recibido: 2019-12-22

Fecha de aceptado para publicación: 2019-12-29

Fecha de publicación: 2019-12-30



Abstract

The relevance of the study is due to the changed trends in University students' training, suggesting an effective solution to educational problems with the help of digital means, among which a special place takes the robotic complex. In this regard, the article for the first time, as an independent scientific direction, attempts to substantiate the theoretical and methodological approach to the use of educational robotic complex as a didactic prototype of modern student training. During the implementation of pedagogical modeling - the leading method of research, educational robotic complex is justified as a methodological basis for the didactic prototype of student training. Taking into account the new trends in the transformation of student training, the article reveals the phenomenology of the educational robotic complex. Based on its results the study establishes the pedagogical terms of the educational robotic complex's realization; substantiates algorithm of didactic designing of a prototype educational robotic systems and proves its effectiveness in educational process of the University. The article focuses materials on providing methodological assistance to University teachers and students in the development and use of educational robotic complex in the educational process of the University. It gives recommendations for teachers, methodologists, University managers and students.

Keywords: educational robotic complex; algorithm for design of robotic complex; didactic prototype; instrumental platform of robotic complex; information and educational environment; pedagogical modeling; digital technologies.

Resumen

La relevancia del estudio se debe a las tendencias cambiantes en la capacitación de los estudiantes universitarios, lo que sugiere una solución efectiva a los problemas educativos con la ayuda de medios digitales, entre los cuales un lugar especial ocupa el complejo robótico. En este sentido, el artículo, por primera vez, como una dirección científica independiente, intenta justificar el enfoque teórico y metodológico del uso del complejo robótico educativo como prototipo didáctico de la formación moderna de los estudiantes. Durante la implementación del modelado pedagógico, el método líder de investigación, el complejo robótico educativo se justifica como una base metodológica para el prototipo didáctico de la formación de los estudiantes. Teniendo en cuenta las nuevas tendencias en la transformación de la formación de los estudiantes, el artículo revela la fenomenología del complejo robótico educativo. Con base en sus resultados, el estudio establece los términos pedagógicos de la realización del complejo robótico educativo; confirma el algoritmo de diseño didáctico de un prototipo de sistemas robóticos educativos y demuestra su efectividad en el proceso educativo de la Universidad. El artículo enfoca los materiales en proporcionar asistencia metodológica a los docentes y estudiantes universitarios en el desarrollo y uso del complejo robótico educativo en el proceso educativo de la Universidad. Ofrece recomendaciones para profesores, metodólogos, gerentes universitarios y estudiantes.

Palabras clave: complejo educativo robótico; algoritmo para diseño de complejo robótico; prototipo didáctico; plataforma instrumental de complejo robótico; información y ambiente educativo; modelado pedagógico; tecnologías digitales



Introduction

The Relevance of the Research

Robotics is one of the newest branches of modern science, which has already emerged as a result of interdisciplinary interactions of electronics, Cybernetics, control theory, computer and information technology, Informatics (Ladygina, 2016; Leyzberg, Spaulding & Scassellati, 2014; Paypert, 1989; Popova, 2015; Pustyl'nik, 2017; Karpenko, Fokina & Shirokova, 2017; Ruslyakova et al., 2019; Tikhonova, 2019). The achievements of this newest branch of science have an intensive impact on the quality of training of a University student. Today, on the basis of common grounds in the educational process of the University, the basic elements of the educational robotic complex are successfully used, harmoniously fitting into the teaching of subjects, in additional education, in extracurricular activities of the student on the basis of modified requirements of educational rules and regulations (Ruslyakova et al., 2019). It is established that in the modern educational process of the University the educational robotic complex is effectively used in the preparation of teachers of preschool, primary and inclusive education, bachelors and masters in the areas of Technological education and Vocational training (Grebneva, 2016; Kalashnikov & Bondarenko, 2016; Karlov, 2016). It plays a leading role in the formation of algorithmic and engineering thinking of the student, in the development of educational motivation of the individual to innovative types of professional activity (Karchevsky & Karchevskaya, 2016). Robotic complex is also an educational priority in the system of professional development of teachers, specialists of working professions, contributes to the successful socialization of young people with disabilities, etc. (Leyzberg, Spaulding & Scassellati, 2014). It is proven, today, robotics is a didactic prototype of the modern training of the future specialist, intensely affecting set of pedagogical interaction between the student and the educational environment forming the complex of creative qualities and abilities of the individual expected not only by the modern labor market, and scientific spheres, to solve problems of development of artificial intelligence and other innovative areas of scientific picture of the world (Ladygina, 2016; Popova, 2015). In connection with these trends, the interest of specialists and researchers in the design and implementation of the robotic complex as a didactic prototype of the University student training is characterized by increased attention. This article is the first attempt to substantiate the theoretical and methodical grounds for the use of educational robotic complex as a didactic prototype of modern student training. Taking into account the new trends in the transformation of modern student training, the article reveals the phenomenology of the educational robotic complex. Based on the results of the study it establishes pedagogical conditions for successful realization of the educational robotic complex; also, it presents an algorithm for designing a didactic prototype robotic system and proves its effectiveness in educational process of the University. The materials of the article are focused on providing methodical assistance to teachers and students in the development and use of educational robotic complex in the educational process of the University.

Literature Review

Radical transformations of the University educational process, mediated by the implementation of the robotic complex, are noted in a significant number of studies that served in the process of this study as a methodological basis for solving the tasks set



(Grebneva, 2016; Kalashnikov & Bondarenko, 2016; Karlov, 2016; Paypert, 1989; Popova, 2015; Ruslyakova et al., 2019; Tikhonova, 2019). It is established that the studies devoted to educational robotic complexes are focused on the problems of engineering training of students (Kalashnikov & Bondarenko, 2016). By the beginning of XXI st century priority in the research starts to be given to the development of the methodological foundations of robotics as an interdisciplinary science encompassing not only STEM - education in the creation of a class of mechanical models for staging thought experiments of the formation of a new world view, but also social and humanitarian education, and social control spheres (Ladygina, 2016). There are also studies devoted to certain aspects of creating a University information environment necessary for the implementation of the educational potential of the robotic complex (Popova, 2015; Ruslyakova et al., 2019; Tikhonova, 2019). These searches predetermined the formation in universities of new specialties mechatronics and robotics, areas of robotics in the field of STEM education, the emergence of academic disciplines "Fundamentals of robotics", "Industrial robotics, Basics of machine automation and robotics. Adjustments are made in the program Informatics, in the subject area Technology. Innovative directions in pedagogical science are emerging-Android pedagogy and robot pedagogy (Ladygina, 2016; Tikhonova, 2019). A significant influence on modern ideas about robotic systems in the educational process of the University had the works of the laboratory of artificial intelligence of the Massachusetts Institute of technology (Paypert, 1989). Based on the results of the research of this group, many modern educational robotics programs are built. Research by S. Paypert (1989) and his collaborators showed that in programs involving robotic systems, students successfully mastered key metacognitive competencies, especially in the field of creative and critical thinking, and acquire such necessary qualities of a modern specialist as the ability to creative communication and cooperation, making independent heuristic decisions and personal responsibility for them, etc. This form of training S. Paypert refers to as constructionism. According to this concept, a student learns not when information is put in his head, but when he actively and independently constructs it. Based on extensive research in the field of cognition, psychology, evolutionary psychology and epistemology S. Paypert shows how using the method of constructionism in the process of using robotics, a student masters the method of learning from his own practical experience. It is established that at the present stage, the bulk of research is devoted to the problems of training a University teacher to use a robotic complex in the educational process. To implement this important problem at this stage, a significant number of program materials, educational and methodical recommendations, manuals, textbooks (Kalashnikov & Bondarenko, 2016; Popova, 2015; Pustynnik, 2017) have been developed.

The course of the study establishes that, despite the considerable amount of research and active interest of modern specialists to modify the trends of the students' training at the University, involving the effective solution of educational tasks using robotic systems in the study of this problem many pressing questions that require scientific solutions remain open. Among such issues, as an independent scientific direction, the priority position is occupied by the theoretical and methodical justification of the educational robotic complex as a didactic prototype of modern student training. The study of this aspect is the purpose of this study.

Results and Discussion



The Phenomenology of the Educational Robotic Complex

It is established that the writer, science fiction writer Karel Chapek, proposed the term robot in 1920 to its readers. It comes from the Czech word *robota*, which means hard monotonous work or penal servitude (Popova, 2015). In modern scientific circulation, the discourse of a robot is considered as an automatic device for carrying out production and other operations according to a certain program (algorithm). The concept of technology includes technical products that did not previously exist in nature and manufactured by man for the implementation of any activity: machines, mechanisms, equipment, apparatus, devices, tools, devices, etc. (Tikhonova, 2019). Writer A. Asimov in the science fiction story «Liar» (1941) first used the concept of robotics as an automatic device designed to protect a person. The peculiarity of the modern information society is technically mediated, open, instant access to obtaining and transmitting large amounts of information or knowledge intended for a person. Fast remote communications through information networks have significantly changed social relationships and the nature of human interaction. The functional capabilities of artificial cognitive systems are constantly expanding; the thinking process is no longer belonging only to living organisms (Popova, 2015). Cognitive Sciences, concepts, theories, principles and new models of cognitive systems with perception, learning, human interface are developing. Robotic laboratories create advanced Autonomous machines and robots that promote human-machine interaction. In this regard, there is an urgent need to adapt the structure, content and technologies of the educational process of the University to the use of robotics, Android technologies and other achievements of the digital world. The structure and content of the phenomenon of robotics are considered today from the standpoint of applied science, engaged in the development of automated systems and based on disciplines such as mechatronics, physics, Cybernetics, electronics, mathematics and computer science, and from the standpoint of technology related to the development and application of robots and computer control systems. In the educational environment of a modern University, robotics has the status of a new interdisciplinary field of study, integrating physics, mechatronics, computer science, mathematics, Cybernetics with biology, philosophy, sociology, psychology and other disciplines. This integration allows to successfully involving students in the process of innovative scientific and technical creativity in the design, modeling, and programming of robotic systems. In connection with the established trends in the research studied the basic directions of implementation of the robotic complex in the educational process of modern universities:

- Classroom activities (implementation of training projects, preparation of demonstration experiment, experimental facilities for practical work, implementation of training workshops);
- Extracurricular activities (creative design work of students, participation in competitions, Olympiads and scientific conferences, including their remote and network forms of implementation);
- Activities in the system of additional education (club, circle, research).

It is established that despite the positive results of the use of robotics in the educational process of the University (mainly in engineering and other technical areas of training), extracurricular forms of design and implementation of robotic systems dominate students. This is explained, on the one hand, by the insufficient development of



technologies for the use of robotics in the educational process, on the other, by the insufficient level of training of teachers for this kind of activity, the lack of the equipment of classrooms with modern technology, the lack of necessary textbooks and guidelines for students and teachers (Ruslyakova et al., 2019).

3. 2. Pedagogical Conditions for the Implementation of Educational Robotic Complex in the Educational Process of the University.

The study substantiated and experimentally confirmed the effectiveness of pedagogical conditions for the implementation of educational robotic complex in the preparation of University students, grouped by the objectives of educational activities.

1. Conditions caused by environmental factors:

- Lego environment of robot control (Microsoft Robotics Studio, the Parallax Boe-Bot, Mind Strom);

- Environments that support popular programming languages (C#, Visual Basic);

- environments of robotic constructors. They provide an opportunity to manipulate not only virtual, but also real objects, which is important for the successful development of educational material by students with different perception channels;

- Virtual environments (Visual Simulation Environment). They allow not only controlling the programmed robots, but also directly to create the surrounding objects. It is proved that if students with different interests (computer graphics, design, and programming) are in the audience, they can be grouped and assigned responsibilities: someone programs a robot; someone creates an environment, designs a program, draws up a portfolio, etc.

Also, this group may include the conditions associated with the organization of the educational process: the distribution of the classroom Fund, the provision of the educational process with robotics tools, the selection of students for research projects, the organization of leisure activities and self-government;

2. Psychological and pedagogical conditions determined by individual and personal characteristics of the subjects of the educational process. The basis of this group of conditions are individual characteristics and the system of relations of subjects of educational process: focus on increased usage of the robotic complex, the ability to self-development, cognitive activity, possession of skills of self-regulation of behavior and activity, ability to establish personal and professional contacts, development of general and cultural abilities and skills.

3. Conditions caused by interactions of subjects of educational process: teacher-student, teacher-teacher, student-student and are connected with such factors as quality of pedagogical communication; competence of University teachers in a choice of tools of robotics and methods of training adequate to didactic tasks; in possession of communicative and control-estimated competences, in correctness of their use at achievement of the purposes of educational robotic complex;

4. Conditions determined by non-standard approaches to scientific and methodical support for the implementation of the robotic complex. The basis of this group of conditions are transformation of the educational environment from a source of knowledge



in the full participant of creation of new information, which modified the nature of the interaction between teacher and student and expanded the educational activities of student information activities; network communication; modeling of the studied objects, their relations and processes; formalization of information; creation of a computerized educational resource; use of instrumental information platforms. Information function gradually fades into the background, giving way to the functions of design, construction, programming, planning, forecasting, and communication. There is a possibility of expansion of hypertext and hypermedia structural forms of representation of the studied material; alternative types of educational and methodical materials (electronic textbook, electronic tests, modeling tools of educational material, training and controlling software, etc.). Spatial and temporal boundaries are being expanded for communication, information exchange, access to electronic libraries, encyclopedias, dictionaries and other information resources. The nature is updated of educational tasks' presentation to students through greater clarity, variability, expansion of the thesaurus, the use of situations and tasks complex of different levels of complexity, increasing the number of information resources to find the necessary knowledge, electronic lecture notes, Bank of control tests, process maps, samples of work, regulatory requirements, and multi-level educational and professional tasks. There are opportunities for constant (online) monitoring of the student's educational work, correction of its progress and directions of searches in solving educational and professional problems with the help of established means of the robotic complex.

3. 3. The Algorithm for Designing of a Didactic Prototype of Educational Robotic Complex

In the course of the study, it is proved as a software the complex providing the functionality of designing, constructing, and programming, planning, and forecasting the phased implementation of the robotic complex in the educational process of the University.

The first stage of the algorithm. Formulation of the objectives for the use of robotics in the educational process of the University:

- Demonstration of the possibilities of robotics as one of the key areas of the educational process;
- Demonstration of the role of the educational subject in the design and use of robotics;
- improving the quality of educational activities: deepening and expansion of subject knowledge, the development of experimental abilities and skills, improving knowledge in the applied field of knowledge of the subject, the formation of abilities and skills in the field of technical design, modeling and construction;
- Development of the student's motivation, needs, cognitive interest in the study of the discipline;
- strengthening of profile preparation, orientation to the chosen profession (Kalashnikov & Bondarenko, 2016; Popova, 2015).

The second stage of the algorithm. Programming of basic content of the training material.



The development of the structure and content of didactic materials is carried out based on integration of didactic and media content of the robotic complex (symbolic information, static, dynamic and sound visual series).

The main principle of this stage-the information is presented gradually, assuming the presence of the results of control actions on the part of the student. Methods of assimilation's organization of the studied information are a system that contributes to the versatile development of the student and contain modeling, fixing and controlling components. Mandatory content includes tasks, materials and instructions for independent work and practical training, for observations and experiments, tasks and questions to test knowledge and feedback, exercises to consolidate knowledge and skills, tasks and links to previously studied material, as well as components aimed at establishing inter-subject and interdisciplinary links;

The third stage of the algorithm. The processual part. The study proves that the implementation of the processual part of the tools for the robotic complex is based on the possibility of establishing various forms of student interaction with multimedia educational content: manipulation of screen objects; linear navigation (scrolling within the screen or moving from one slide to another); hierarchical navigation (selection of subsections using menus, trees); interactive help, called with buttons on the navigation panel (the most effective one is context-sensitive help); feedback (the resource responds to the user by evaluating the correctness of the task performed). These answers are recorded on the screen. If further progress in educational materials depends on the results of the task, then there is a correction of the educational trajectory; constructive interaction (the resource allows you to create and configure screen objects, as well as manage them; users can add new nodes and hyperlinks to existing ones, expanding the existing structure of the multimedia application). Based on the obtained information, an optimal sequence of studying the material is created.

The fourth stage of the algorithm. Implementation of means of student educational achievements' assessment. It provides current and effective information accumulation on the student training and provides them upon completion of work information in the report. Electronic testing is a formalized type of control. Working with training control tests and self-control systems can provide explanations in the case of an incorrect answer and recommendations for the use of a textbook, thesaurus or additional material. In case of placement of an electronic educational resource on the Internet-server of an educational institution, it may provide the teacher information about the results of each student's work through e-mail resources.

The fifth stage of the algorithm. Implementation of student activity management tools. It provides the student with the opportunity to freely choose one of the three modes of operation in the educational environment of the robotic complex-self-government, differentiated management by the teacher and management by the software of the robotic complex. The first two types of management are determined by the human factor-the student and the teacher and the level of communication between them. The mode of the software means of training provides management of educational process during passing by the student of an individual trajectory of training and in this case, robotic means fix all achievements and mistakes of the student according to the set program.



Conclusions

The study confirms the theoretical and practical importance of pedagogical substantiation of approaches to the implementation of the robotic complex in the educational process of the University. The study proves robotic system is a didactic prototype of the future specialist's modern training, intensely affecting set of pedagogical interaction between the student and the educational environment forming the complex of creative qualities and abilities of the individual expected not only by the modern labor market, and scientific spheres, to solve problems of development of artificial intelligence and other innovative areas of scientific picture of the world. In the modern educational process of the University, the educational robotic complex is effectively used in the preparation of teachers of preschool, primary and inclusive education, bachelors and masters in the areas of Technological education and Vocational training. It plays a leading role in the formation of algorithmic and engineering thinking of the student, in the development of educational motivation of the individual to innovative types of professional activity. Robotics is also an educational priority in the system of professional development of pedagogical workers, working professionals, contributes to the successful socialization of young people with disabilities etc. In connection with these trends, the interest of practitioners and researchers in the implementation of the robotic complex as a didactic prototype of student training will be of increased attention. Taking into account the new trends in the transformation of student training, the article reveals the phenomenological essence of the educational robotic complex as a new interdisciplinary field of study integrating physics, mechatronics, computer science, mathematics, Cybernetics with biology, philosophy, sociology, psychology and other disciplines. Based on the results of the study the pedagogical terms of realization of the educational robotic complex are established: environmental factors, organization of educational process, interaction of subjects of educational process, innovative approaches to scientific and methodical support of educational process, the priorities for the design, construction, programming, planning, forecasting, communication; the algorithm for designing a didactic prototype of an educational robotic complex is substantiated: the purpose of using a robotic complex – programming of the basic content of educational materials – implementation of means of evaluating students' educational achievements – implementation of means of managing students' activities. The effectiveness of the didactic prototype is proved by the results of monitoring the process of student preparation. The study reveals a small aspect of the complex problem of student modern training. It does not exhaust all aspects of the problem. The priority task of further research is the conceptual justification of technologies for training University teachers of all cycles of disciplines to work in environmental conditions of the robotic complex.

Bibliography

- Grebneva, D.M. (2016). The study of robotics elements in the basic course of computer science. URL: <http://festival.1september.ru/articles/623491>.
- Kalashnikov, A.G. & Bondarenko, D.A. (2016). Development of educational and methodical complex based on small-sized anthropomorphic robot. National Association of scientists, 4(20), 16-18.



- Karchevsky, V.P., Karchevskaya, N.V. (2016). Pedagogy of robots. URL: <https://ru.wikiversity.-org/wiki/>
- Karlov, A.E. (2016). History of development and modern methodological problems of robotics. Eurasian scientific journal, 4, 1-4.
- Karpenko, O.M., Fokina, V.N. & Shirokova, M.E. (2017). Robotics as an educational trend. Distance and virtual learning, 5(119), 24-32.
- Ladygina, I.V. (2016). Philosophical aspects of educational robotics. Problems of modern pedagogical education, 53(10), 87-95.
- Leyzberg, D., Spaulding, S. & Scassellati, B. (2014). Personalizing robot tutors to individuals' learning differences. ACM/IEEE International Conference on Human-Robot Interaction, pp. 423–430. Bielefeld. DOI: 10.1145/2559636.2559671.
- Paypert, S. (1989). A revolution in the consciousness: Children of computers and fruitful ideas. Moscow: Pedagogy.
- Popova, T.G. (2015). Educational robotics: a digest of current materials. Ekaterinburg: SBEI APE Institute of education development of Sverdlovsk region.
- Pustynnik, P.N. (2017). Educational robotics for bachelors and masters in the direction of "Technological education". Distance and virtual learning, 3(117), 17-25.
- Ruslyakova, E.E., Pustovoitova, O.V., Kiseleva, Yu.P. & Yakovleva, L.A. (2019). Theory and practice of robotics in the educational process. Higher education in Russia, 28(6), 158-167. Moscow.
- Tikhonova, L.P. (2019). On the relevance of modern digital technologies introduction in education. Bulletin of Cherepovets state University, 1, 203 – 211.