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**TÍTULO:** Pruebas manuales de capacitación sobre el uso de robots biosimilares de pequeño tamaño.

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**RESUMEN:** El estudio descrito en el artículo está dirigido al desarrollo y la prueba de apoyo educativo e informativo dirigido al uso y la implementación de logros científicos en el campo de la robótica para la educación de niños y jóvenes. Los autores utilizaron el modelado del esquema de desarrollo de la robótica educativa. El artículo proporciona la sustanciación de la estructura de apoyo educativo y el contenido para la enseñanza de la robótica basada en el uso de robots biosimilares de pequeño tamaño. Los autores presentaron los resultados de la aprobación de la ayuda a la enseñanza, corroboraron la efectividad del uso del apoyo educativo y describieron el esquema del entorno de innovación para el desarrollo de la robótica educativa.

**PALABRAS CLAVES:** implementación de logros científicos, robótica, uso de apoyo educativo.

**TITLE:** Training Manual Tests on the use of Small-Sized Biosimilar Robots.

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**ABSTRACT:** The study described in the article is aimed at the development and the testing of educational and information support aimed at the use and the implementation of scientific achievements in the field of robotics for the education of children and youth. The authors used the modeling of educational robotics development scheme. The article provides the substantiation of educational support structure and content for the teaching of robotics based on the use of small-sized biosimilar robots. The authors presented the results of teaching aid approbation, substantiated the effectiveness of educational support use, and described the scheme of the innovation environment for the development of educational robotics.

**KEY WORDS:** implementation of scientific achievements, robotics, educational support use.

**INTRODUCTION.**

The transition of the world economy to a new technological structure assumes a wide use of high technologies and equipment with a high level of automation and robotization. Therefore, now it is necessary to begin the popularization of the engineer profession actively since secondary school, to introduce the basics of robotics in the education of children and youth. At the same time, there is the problem associated with the absence of educational and methodological support for the preparation of schoolchildren, aimed at the development of scientific and technical creativity in the field of robotics (Ivanova & Sharafeeva, 2016).

In order to solve the abovementioned problem, it is necessary to determine the trajectory of activity, which includes the analysis of the available training and information support, the selection of content, the development of educational support structure; the selection of pedagogical technologies for the educational process organization and the methods of work with educational materials. Then, it is necessary to carry out the approbation of the training provision, the correction and finishing if necessary, and then the preparation for publication and replication for distribution and the application in education of children and youth.

## **DEVELOPMENT.**

### **Purpose of the study.**

The purpose of the study is the development and the testing of educational and information support aimed at the use and implementation of scientific achievements in the field of robotics for the education of children and youth.

The purpose defines the research objectives:

- The creation of an innovative educational environment, which includes the leading sites for the development of robotics.
- The development of mechanisms for network interaction between universities, schools and advanced developers of modern robotic systems.
- The development of a theoretical module in the form of teaching aids on the basics of robotics, laboratory workshops and their preparation for approbation.
- The establishment of links between the authors of the educational and information support and a testing site, also on the basis of web-technologies.
- The development of a plan for educational materials testing.
- The approbation of educational and information developments on approbation sites.
- The processing and presentation of results.

In order to attract the advanced developments of modern robotic systems, the teachers of the Elabuga Institute of the Kazan Federal University established a network interaction with the scientific and production association "Android Technology". The experts of the scientific and production association (SPA) are engaged in the creation of robotic systems for various purposes, including small-sized robots that have the potential for the use in the education of children and young people. For example, the robots AR series 100 and MR series 200 can be used to teach students modern robotic technology. So the anthropomorphic robot AR-100 believably simulates the basic movements of a human body, including the true (with the lifting of the foot from the surface) upright walking, sporting and dancing movements (Ivanova, 2016).

In April of 2015, the designers of the SPE "Android Technology" handed over android and biomorphic robots to teachers who started to study their properties, capabilities and sensitivity sensors. Analyzing the educational capabilities of robots produced by "Android technology", the teachers came to the conclusion that they serve as convenient platforms for scientific and technical research and creativity. Biosimilar robots allow to fill methodological spaces inherent in robot-designers. They enable to interact with androids and other biosimilar robots and also to program them in accordance with the field of application, which reflects the vector of modern technology development. The use of biosimilar robots allows you to move away from the concept of fine motor skills and develops innovative thinking among children, which is an alternative to lego robots for the development and the expansion of motivation to engage in robotics (Ivanova, 2016). Therefore, based on the network interaction of teachers with the experts from SPE "Android Technology", the project "RoboStart" began its work.

After the substantive and methodological analysis of the available manuals on robotics from various authors, the instructors determined the structure and the content of the author's teaching aids - the teaching aid "The Basics of Robotics", the laboratory workshops "The programming of the android

robot AR-101M" and "The programming of the biomorphic robot MR-200" (Picture 1). The teaching aids are designed for students interested in robotics. The content of the teaching aids is targeted at 7-11 grades of general education schools.



Figure 1. Teaching aid appearance

After the analysis of available textbooks for schoolchildren and students, the main content modules were determined, which were included in the author's textbook "Fundamentals of Robotics" (<https://www.dvfu.ru>). The manual consists of 5 modules:

1. History of development and the current state of robotics.
2. General information about robots.
3. The programming of robots.
4. The basics of artificial intelligence.
5. Social robotics.

Each module of the teaching aid is an independent content unit, which allows a teacher working on this teaching aid to build the trajectory of learning in an arbitrary sequence (Galimova, 2016).

Let us consider the structure and the content of the author's manual "Fundamentals of Robotics" in more detail (Galimova & Galimullina, 2016). The manual begins with the description of safety

techniques, since students need to know how to behave in a computer class and during the work with a computer. When the students have studied the safety methods, one may begin to study the main content of the textbook, which begins with the introduction that immerses students in an interesting and an exciting world of robots.

All chapters of the teaching aid consist of paragraphs. The content of each paragraph includes such mandatory control points as "Remember!!!", "Exercises", "Questions for reflection", "It's interesting!!!", "Remember!!!" (Figure 2). The structure of the manual also includes the "Glossary", which contains all the definitions used in this tutorial.

Each component of the manual has its meaning. Students will know that it is necessary to remember, which basic idea of a chapter or a paragraph they need to know. Questions for reflection contribute to the learning and, at the same time, to the repetition of the studied material. Exercises help learners to learn a topic more deeply and encourage them to perform creative individual assignments on the topic, which makes the learning process more interactive and interesting.

The component "It's interesting!!!" contributes to the development of student cognitive skills, the acquisition of additional interesting information about various facts, about the known scientists and inventors, about their inventions, etc. (Galimullina, 2016).

Laboratory practical studies are devoted to the programming of the android robot AR 100 series (Ibatullina, 2016) and the biomorphic robot MR series 200 (Galimullina & Galimova, 2016). The manuals contain information on the main elements of the programming language AR Basic Studio control, the types of data and the implementation of the basic algorithmic structures.

**Это интересно!!!**

Карел Чапек родился 9 января 1890 года в Мале-Сватонёвице близ Трутнова, Австро-Венгрия (ныне Чешская Республика), в семье врача Антонина Чапека (1855-1929): он стал третьим и последним ребёнком в семье. Чапек начал писать в возрасте четырнадцати лет. Его ранние произведения, такие как «Простые мотивы», «Истории фей» публиковались в местной газете Nedele.

К Чапек, слабое здоровье которого было подорвано событиями 1938 года (Мюнхенский сговор), скончался от двустороннего воспаления лёгких 25 декабря 1938 г., полученного в результате работ по ликвидации наводнения незадолго до полной немецкой оккупации Чехословакии.

В отличие от многочисленных писателей-фантастов, использовавших затем слово «робот» для обозначения человекоподобных неживых механизмов, Карел Чапек назвал этим словом не машины, а живых людей из плоти и крови, только созданных на специальной фабрике.

**Вспомни!!!**

**Сигнал** — материальный носитель информации, используемый для передачи сообщений в системе связи. Все сигналы можно разделить на два основных вида: аналоговые и дискретные.

**Аналоговый сигнал** — сигнал данных, у которого каждый из представляющих параметров описывается функцией времени и непрерывным множеством возможных значений.



Рис. 2.2. Аналоговый сигнал

В случае когда параметр сигнала принимает последовательно во времени конечное число значений (при этом все они могут быть пронумерованы), сигнал называется **дискретным**.



Рис. 2.3. Дискретный сигнал

**Запомни!!!****Законы робототехники**

1. Робот не может причинить вред человеку или своим бездействием допустить, чтобы человеку был причинен вред.
2. Робот должен повиноваться командам человека, если эти команды не противоречат Первому Закону.
3. Робот должен заботиться о своей безопасности, пока это не противоречит Первому и Второму Законам.

**? Вопросы для размышления**

1. Как назывались первые современные роботы?
2. Где и в каком году появился первый робот, предназначенный для практического использования? Приведите пример.

**Упражнение**

1. Заполните таблицу по образцу:

Этапы	Характерные черты	Основные открытия
I Глубокая древность	Первый исторический этап движения человечества по пути создания роботов характеризуется обилием мифов и легенд о механических существах, а также созданием первых довольно совершенных для своего времени человекоподобных автоматов – «андрондов».	Водяные часы – Клепсидры и т.д.

Figure 2. Structural components of the teaching aid "Fundamentals of Robotics".

A large number of examples of program listings are considered and the tasks for independent solutions are given in these manuals. The content of the workshops is divided into lessons. Each lesson unfolds according to the following scheme:

1. "Lesson plan" - students are introduced to the sequence of actions to acquire new knowledge and practical competencies.
2. The theoretical section ("Read!") - here is the whole theory necessary for the implementation of practical actions.
3. Demonstration by a teacher ("Experiment!") - this section contains information about the things a teacher demonstrates in this lesson.
4. The section "Attention!" or "Caution!" warns the students about possible errors in work.

5. The section "Homework" contains the tasks for homework, which may include the activities for the management of robots. Therefore, the robotic class should be open for free access of children at any time so that the student can work with the robots themselves.

In order to determine the strengths and the weaknesses of the textbooks developed by us, they were tested in a real educational process.

### **Materials and methods of study.**

In order to test the teaching aids, the SPE "Android Technology" sent 12 biomorphic and 6 android devices ready for programming, as well as 10 spider robots in a disassembled form to the IT-Lyceum of the Kazan Federal University. Robotic classes appeared in the Lyceum. From February to May 2017, the experiment was conducted in which the Lyceum students from grades 8 and 10 participated. The teachers of Yelabuga Institute of KFU, as well as the students participating in the project "RoboStart" acted as teachers since 2015. The children immersed in the process of studying the basics of robotics with great interest using author textbooks, as well as the designs of new robotic systems and the possibilities of their programming. Thus, the training was carried out in two directions, so the classes were conducted one by one, two lessons per week in each grade.

The first lesson was devoted to the mastering of robotics fundamentals. During the lesson the students studied theory in an interactive form with the use of electronic accompaniment, they worked in groups, solved practical tasks individually and in a team.

During the classes, the following interactive teaching technologies were used: the method of cooperative learning and the joint work of a group of students with a teacher. The second lesson is aimed at the development of practical skills in robot management. During this lesson, students studied new possibilities of robots, analyzed ready-made program codes, modified them, made new programs and came up with new tasks for robots in pairs.

In order to determine the effectiveness of the educational information provision developed by the authors, the survey was conducted among the students. The questions of the questionnaire reflect the evaluation of the teaching aid components and also the analysis of the course of study perception, the attitudes towards lessons, as well as the student desire to continue the teaching of robotics fundamentals.

The questionnaire contains 13 questions. The answers to questions offered the lyceum students to choose from four options: unsatisfactory, satisfactory, good and excellent, or to express their opinion. Let's demonstrate the questions of the questionnaire:

1. What's your evaluation concerning the informative content of the training manuals on robotics?
2. What's your evaluation concerning the content clarity and structure of training manuals on robotics?
3. What's your evaluation concerning the interest and the usefulness of the subject?
4. What's your evaluation of the variety of tasks?
5. In your opinion, is there an advantage in the study of this discipline? If so, what is the advantage of this discipline study?
6. What's your evaluation of electronic accompaniment quality concerning the theoretical part of the subject?
7. What's your evaluation concerning the usefulness of the laboratory workshop during lessons?
8. What's your evaluation concerning the quality of the material presentation?
9. Do you like to fill in the workbook?
10. Was the relationship of the discipline to the future profession clear? Is it useful?
11. Did you engage in other matters during the lesson?
12. Specify the shortcomings of the subject.
13. Specify the advantages of the subject.

## Results and discussion.

Let's demonstrate the analysis of lyceum student survey results, 90% of whom are tenth graders, and the remaining 10% are eighth graders. The test participants' answers to the questions suggesting the evaluation of the learning process by four-level scale are presented on Figure 3.

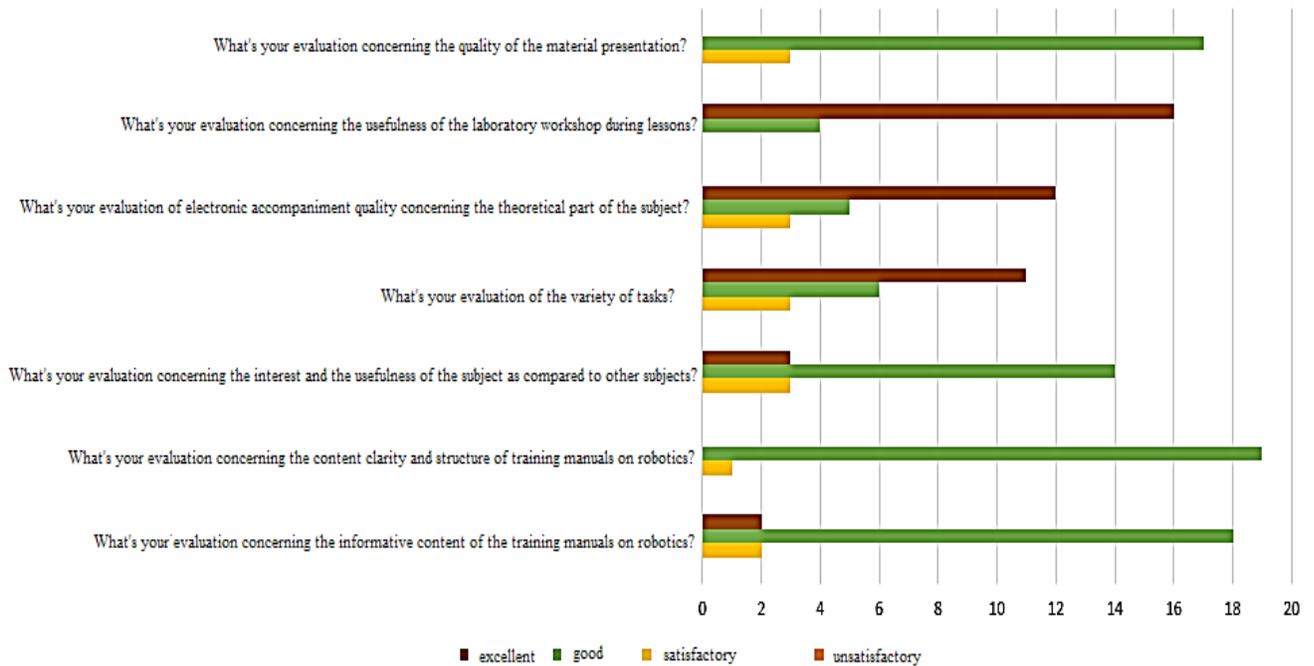


Figure 3. Evaluation of the learning process by four-level scale

The diagram shows that there are no unsatisfactory answers.

Almost all respondents rated the informative content of the teaching aids as "good" (Figure 4).

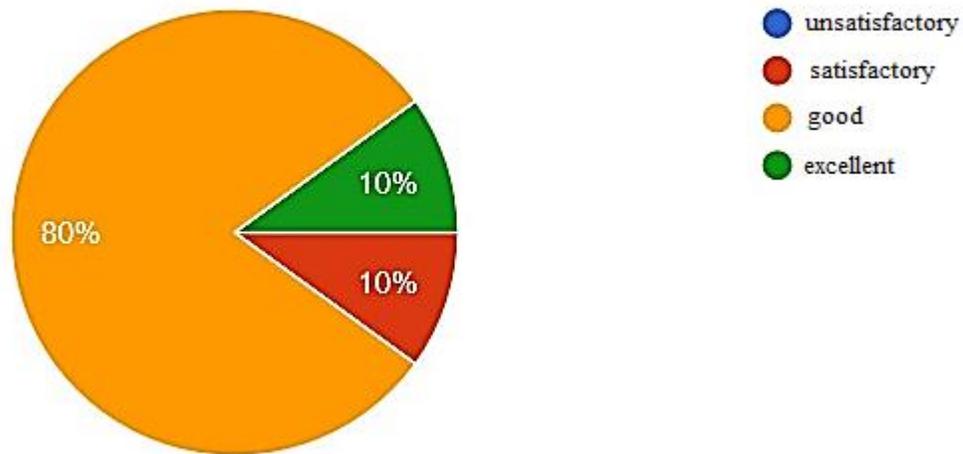


Figure 4. Evaluation of teaching aid informative content

55% of the lyceum students rated the variety of assignments as "excellent" (Figure 5).

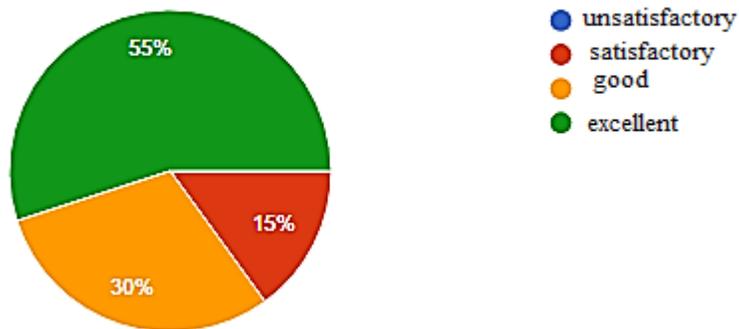


Figure 5. Evaluation of task diversity

The overwhelming majority of respondents rated the quality of the electronic accompaniment for the theoretical part of the subject as "good" (Figure 6).

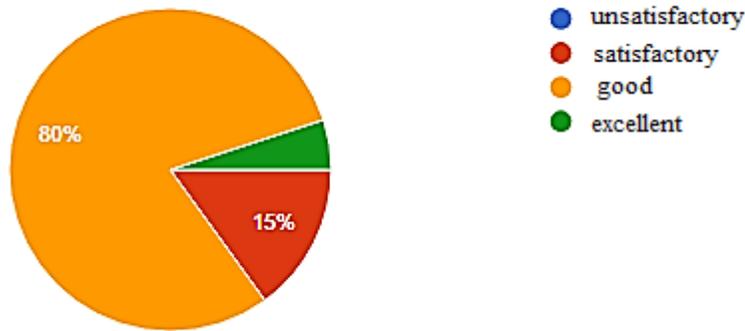


Figure 6. Evaluation of electronic accompaniment quality for the theoretical part of the subject  
 One may consider the positive responses of 80% of the survey participants to the question about the usefulness of laboratory workshop use during the lesson as a positive result, of course (Figure 7).

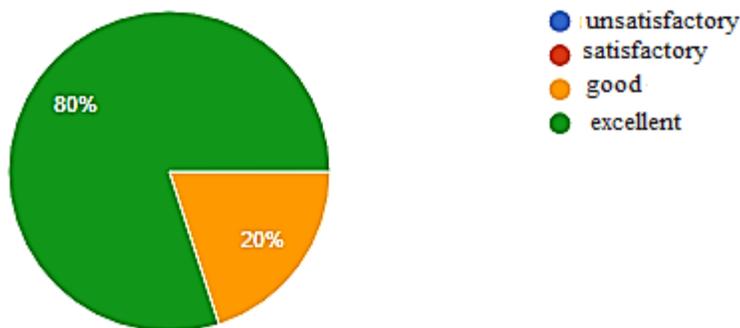


Figure 7. The evaluation of the laboratory workshop usefulness during lessons

After the survey and questioning, the lyceum students expressed the opinion on the positive role of the teaching aids and workshops in the development of interest for robotics and the practical application of the gained knowledge. Most of the lyceum students unequivocally spoke about the orientation of the educational material on the development of engineering and technical creativity. Ten-graders noted the vocational orientation of the training course. The students talked about the fact that the textbook is interesting for reading, especially the module "The history of development and the current state of robotics".

Within the approbation, the textbooks received positive feedback from the computer science teachers with the highest qualification category. In their opinion, the teaching aids contribute to the development of scientific and technical creativity of schoolchildren, contain a sufficient amount of educational material of an applied nature, demonstrating the connection of robotic devices with human life. The teachers noted that the manuals provide a sufficiently good level of the motivational sphere development for the learning process, which is carried out by cognitive activity stimulation through the problematic presentation and personal significance of the learning content (Galimova & Galimullina, 2016).

Approbation showed that the successful organization of the educational process requires the electronical support of robotics fundamentals study, which was developed by the authors in accordance with the modern requirements for the presentation of information, and contains visual diagrams, illustrations, video, etc. In order to fix the results of the independent work of students and further training trajectory development it is necessary to introduce the work in workbooks. Therefore, the authors of the textbooks have prepared and tested the abovementioned educational information support. A workbook contains a large number of various tasks, for example, the filling in of spaces in the schemes, the performance of test tasks, the solution of crossword puzzles, the establishment of correspondence, the writing of essays, the assignments for classification, generalization, etc.

Based on teaching aid approbation results of training manuals on robotics, the following conclusions were drawn:

- The approbation was successful, which was shown by the survey and the questioning of IT lyceum students.
- The authors develop and partially use the electronic support in testing.

- In order to fix the results of student independent work and develop the trajectory of further education, the workbooks were applied and now they are in the process of completion.
- The training manual "Fundamentals of Robotics" is universal one and does not depend on robot-technical platforms used in training. The manual itself did not change the structure, but it was supplemented with new information, diagrams and drawings.
- The structure and the content of the laboratory workshops did not undergo any special changes, but only supplemented with new software codes.

In general, the methodological approaches implemented by the authors turned out to be successful and can be projected for a wide range of educational institutions. The assumptions about the need for the infrastructure functioning of the network community of university teachers, teachers, SPE representatives, including those based on web technologies, were confirmed (Galimullina & Lyubimova, 2015; Ljubimova & Galimullina, 2014; Lyubimova et al., 2017).

## **CONCLUSIONS.**

We proposed the approaches to the development of educational robotics in the future. The authors came to the conclusion that it is necessary to create an innovative educational environment for the introduction of robotics into the educational process, the participants of which are not only universities and schools, but also scientific and production organizations. Thus, in order to introduce robotics in schools it is necessary:

- To establish laboratories for robotics at educational institutions.
- To develop a model range of small-sized robots (wheeled, caterpillar, air, android, biomorphic, etc.) to equip the laboratories for educational robotics.
- To summarize and to disseminate the experience of pilot projects on the introduction and the use of robotics at schools.
- To organize regional training and retraining centers based on higher education institutions.

- To organize classes, competitions and conferences on the basis of small-sized biosimilar robotic systems.

Summing up, let us present the abovementioned conclusions and the results of approbation in the form of the scheme (Figure 8). The scheme of the innovative educational environment proposed by the authors will contribute to the development of scientific and technical creativity among children and young people.

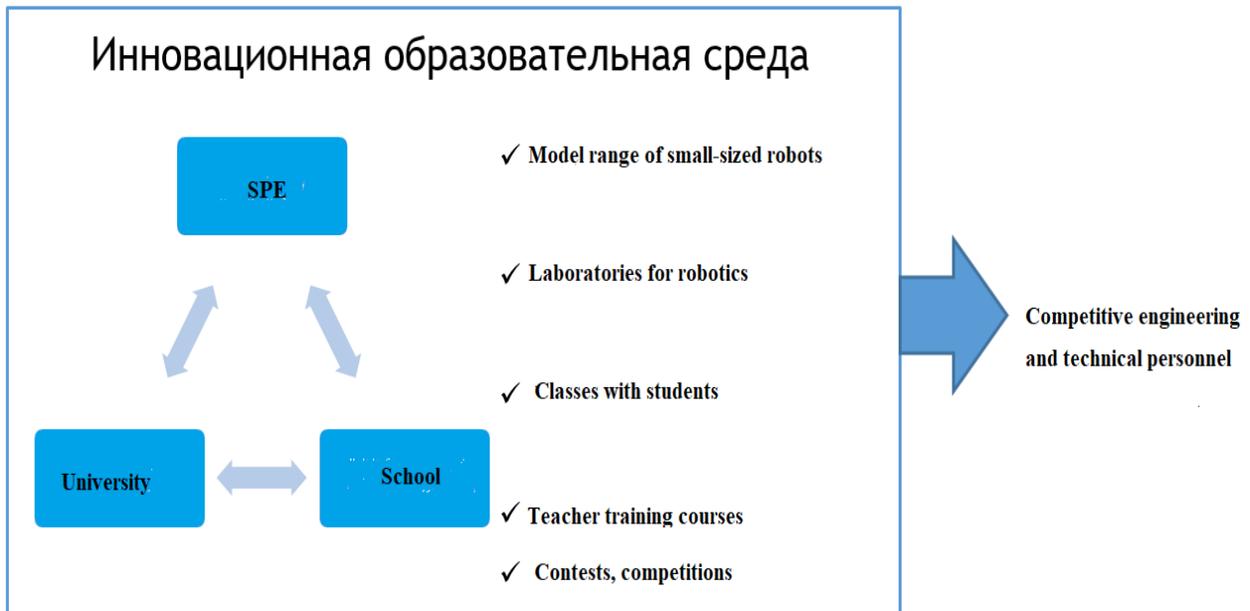


Figure 8. Development scheme for educational robotics.

The results of the work were published in Russian and international publications, and were also reflected in the media, both at the city and at the republican and Russian levels, also in the Teacher's newspaper (<http://www.ug.ru/archive/69709>).

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