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EDUCATIONAL ROBOTICS IN PRIMARY SCHOOL

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Abstract

The following research investigates the pedagogical conditions for implementing the process of teaching universal learning actions to primary school children during the process of teaching robotics in the context of supplementary education. The article describes the mechanism of teaching universal learning actions to primary school children in the process of teaching them robotics. The authors have defined the stages and devised the algorithm of teaching robotics to primary school children. There have been developed and implemented the diagnostic array of tools for comparative assessment of the level of acquisition of universal learning actions of primary school children both in the context of supplementary education and in their primary school curriculum. Constructing the process of teaching robotics in accordance with the stages and algorithms suggested by the authors allows to increase the effectiveness of teaching universal learning actions to primary school children. The article shows that constructing the teaching and educational process of forming universal learning skills during the process of teaching robotics to primary school students has a positive influence on the acquisition level of their cognitive interest. The students who attend robotics clubs have a higher level of reflective self-assessment of the learning activity. There are statistically significant differences in the achieved level of communicative learning skills among the students who attend robotics clubs and those who do not; the children who attend them have better developed communicative learning actions.

Keywords: Educational robotics, primary schoolchildren, universal learning actions

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1. Introduction

The development of robotics is currently driven by the social order of society. Every day we come across new robotic devices in the field of medicine, the public sector and in production, in everyday life. Initiating the development of robotics is an investment in human capital, in future jobs, necessary to create a technically progressive, productive workforce that can adapt in a rapidly changing world. In these conditions, it is important to instil an interest in modern trends in the development of the economy from childhood, investing in future generations.

Robotics contributes to the formation of key research competencies required by modern humans. Society needs specialists with innovative technologies and the ability to adapt to a rapidly changing environment. The training of such specialists should begin as early as possible. Therefore, educational robotics should be introduced at all levels of education, including primary school, because it is at the elementary school age that cognitive processes are actively developing.

Using robotics in the practice of teaching and educational work in secondary school is a new trend in the theory and methodology of polytechnical education. Teaching children to design and assemble simple robots with the use of special educational kits is connected in pedagogical research with the new concept of «educational robotics», an interdisciplinary educational trend, which integrates the knowledge of physics, mechatronics, technology, mathematics, cybernetics and information communication technologies.

2. Problem Statement

With the introduction of Federal Educational Standard of Primary Education (2009) into the system of general education a new aim has problem – organizing the educational process in a way that allows not only to give students educational knowledge and to form skills but also to form «universal learning actions» (cognitive, regulatory, communicative), which ensure mastering key competencies lying at the core of the ability to learn and mastering interdisciplinary concepts. Universal learning actions are a set of methods of various actions that contribute to the active self-development of a student, helping to independently master new knowledge, mastering social experience, and forming a social identity. Having mastered the universal educational actions, the student will not get lost in the incessant flow of information, he will acquire a very important skill – «the ability to learn».

In the last few decades there have been made and released a huge number of robot construction kits with improved and more convenient design (LEGO Mindstorms, Arduino, Crickets and others), which paved the way for popularizing robotics among students of all ages, but currently the most popular one is the group of Lego robot construction kits, which allow to cover virtually all age groups.

The works of Papert (1980, 1990, 1993, 1996) had a great influence on the modern ideas of knowledge and acquiring experience, and many educational programs are based on them. The research of Papert and his collaborators showed that in programs involving robots the students acquire many key skills, especially those which are required in creative and critical thinking, they learn to study and acquire the so called «metacognitive skills». Also, other important qualities of a modern professional are developed, such as the ability to communicate and operate. This form of education is described by specialists as

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«constructionism». According to this conception, children learn not when the information is «placed» in their head, but when they construct knowledge actively, by themselves.

Ohnishi Yoshihiro, et al. (2017) assess the effectiveness of robots in teaching programming to children in primary school. The study of educational robotics for the development of learning styles for schoolchildren is devoted to the article of Budiyanto et al. (2020).

Russian pedagogics have accumulated positive experience of designing educational robotics courses, both with the use of localized materials of LegoEducation and based on their own learning aids.

Thus, Andreyev and Izosimova (2013) point out that the structure of a robotics course may vary, the success is mostly determined by specific characteristics of teaching the course, the correct approach of the teacher and the implementation of the principles of problem- and activity-based teaching. It is important that when organizing the course, the programming and the engineering parts should be planned so that they are interrelated, supporting the motivation to study, on the one hand, and do not lead to the course turning into a game. The highest effectiveness of education will be achieved when the main instruments are the constructions devised by children, in that case the students will be personally motivated to solve the given tasks, and the interaction between the teacher and the student will be done in the form of collaboration.

Vegner (2013) thinks that the process of making a robot implies, firstly, the child's active and creative work which is detailed through solving unconventional tasks and using a big number of variants of solution; secondly, the development of the students' interest in technology, programming and designing, which leads to popularizing the engineering profession and instills the interest in robotics, and thirdly, teaching them the programming skills and developing the logical and algorithm thinking.

In his work Sorokin (2017) analyzes the results of the entrance testing of students who enroll in the elementary module of the course «Robotics». It is shown that it is important to diagnose the children's aptitude for technical and logical thinking.

Budaev et al. (2019) describes the complexities and benefits of a robotics circle in primary school. Bayurova (2019) examines the aspects of the effectiveness of the study of robotics by primary schoolchildren in the framework of extracurricular activities in accordance with the Federal State Standard.

3. Research Questions

The stages of teaching robotics to primary school children can be presented as the interrelation «teacher – primary school child» in the following way. At all stages the teacher keeps the role of a consultant. However, at the first stage the teacher uses, as a rule, the explanation and demonstration methods of teaching: explains to children the peculiarities of assembling a robot. At the other stages the teacher is a consultant who watches the students working but interferes into their activity only on their request. It is obvious that the traditional assessment at school does not reflect the multi-component contents of universal learning actions.

In course of the study the following questions were raised:

- How does the teaching of robotics affect the cognitive, communicative, and regulatory abilities of children?

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- How to assess the levels of formation of universal educational actions of schoolchildren in the new educational reality?

4. Purpose of the Study

The aim of our research was to identify the levels of universal learning actions acquired by primary school children during the process of teaching them robotics.

5. Research Methods

Since 2012 in Russia there has been implemented the program of teaching school children in specialized engineering-technical classes. In accordance with this program there have been bought and spread robotic Lego sets. In the republic of Chuvashia, for example, 124 schools out of 600 received such sets. The pilot testing of the didactic value of teaching robotics to primary school children started in 2013 with the support of the Ministry of Education and Youth of the Chuvash Republic.

In 2013 in Chuvashia the non-profit organization Academy of Computer Graphics created a network of robotics clubs Kulibin.club (https://kulibin.club/), which became the experimentation facility for the research. In the experiment more than 300 primary school children and 7 teachers of the supplementary education system took part.

There were randomly selected 163 school children out of 300. In terms of the gender aspect, boys prevailed (96%). The age ranged from 8to 12. The control group were the schoolchildren of the city of Cheboksary who did not attend the robotics clubs. The control group included 49 children at the age of 10. The experimental work lasted from 2015 to 2019. The inner diagnostic soft he level of universal learning skills was-conducted by the teachers themselves.

During the research there were used empirical methods of research (watching the pedagogical process, survey, conversation, the results analysis, experience study and generalization) and statistical methods (statistical data analysis, qualitative and quantitative analysis of research results).

6. Findings

There have been singled out three main successive levels of acquisition of universal learning actions. At the first (the lowest) level the primary school child in general performs only single operations of the algorithm of assembling robots by the model, their succession is chaotic, and the action in general is badly perceived. At the second (medium) level the child performs all the operations of assembling a robot (actions) which constitute together the action (activity) in general, but the succession of their performance is not fully understood. At the third (the highest) level the child performs all the operations of assembling robots, their succession being well thought-out and, consequently, rational, and all the actions in general being fully understood and perceived. Let us consider the levels of acquisition of universal learning skills: cognitive, regulatory and communicative ones and make their comparative analysis based on the conducted experiment.

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6.1. Changes in the level of acquisition of cognitive universal learning actions of primary school children

The most vivid are the positive qualitative changes in the level of acquisition of cognitive universal learning actions of primary school children (see Figure 1). The experiment revealed that cognitive universal learning actions of primary school children have undergone greatest changes both in the control and the experimental groups. In the experimental group these changes are much bigger: out of 163 people in this group at the end of the experiment 63 students showed that the level of acquisition of universal learning actions became the highest – stable and conscious (a 29% growth in comparison with the control group), while at the low level, when the succession of actions is not thought-out well enough and the action is conducted not very consciously, there were only 19 children left, which shows a 43% decrease. It is quite natural, as the realization of the mechanism of acquiring universal learning actions by primary school students in the context of supplementary education implied the use of the algorithm of teaching robotics, which was used in the process of having classes at all levels of preparation in accordance with the developed stages of teaching robotics. The classes teaching robotics to primary school students were based on entertaining practical activities and lasted 30 to 120 minutes depending on how detailed the description was. The students had an opportunity to learn the working principles of different mechanisms and devices, study many laws of physics and physical phenomena and exploit in practice such concepts as energy, force, movement, different types of constructions and many other things of the fascinating world of technology and physics.

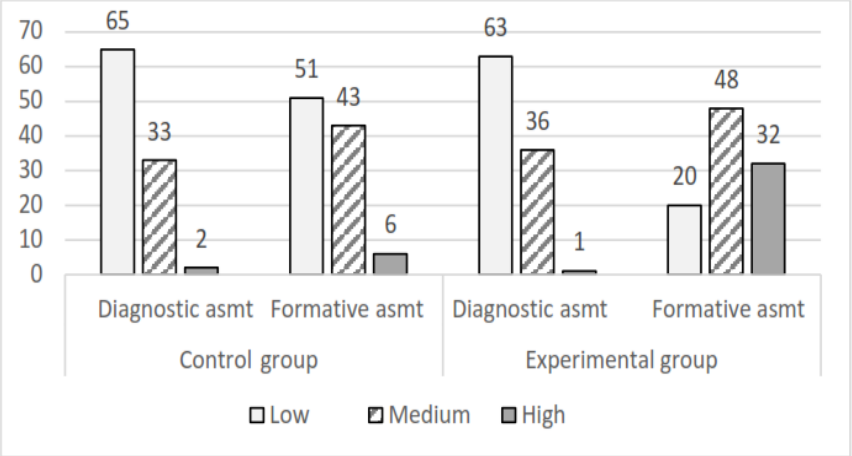

Figure 1. Comparing the changes in the level of acquisition of cognitive universal learning actions of primary school children while teaching them robotics, based on the results of the conducted experiment (in %)

6.2. Changes of the level of acquisition of regulatory universal learning skills of primary school children

The obtained results of the development of regulatory universal learning actions of primary school children clearly prove (see Figure 2), that throughout the process of implementing in practice the mechanism of acquisition of universal learning actions, while teaching robotics in supplementary education

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of primary school children, a big role is played by the algorithm that we have developed for all defined specific stages of teaching robotics.

The technological effectiveness of implementing this mechanism is proved by the growth in figures: out of 163 students of the experimental group 78 children achieved the highest level – the level when the student performs all the operations of assembling robots in a successive, well thought-out and conscious way (a 45% growth in comparison with the control group), while in the control group only 4 out 49 students achieved this level.

There was a considerable decrease (48%) in the number of primary school children who stayed at the low level (when the actions are not conscious and chaotic) in comparison with the number of such students in the control group, where the decrease made up only 14%).

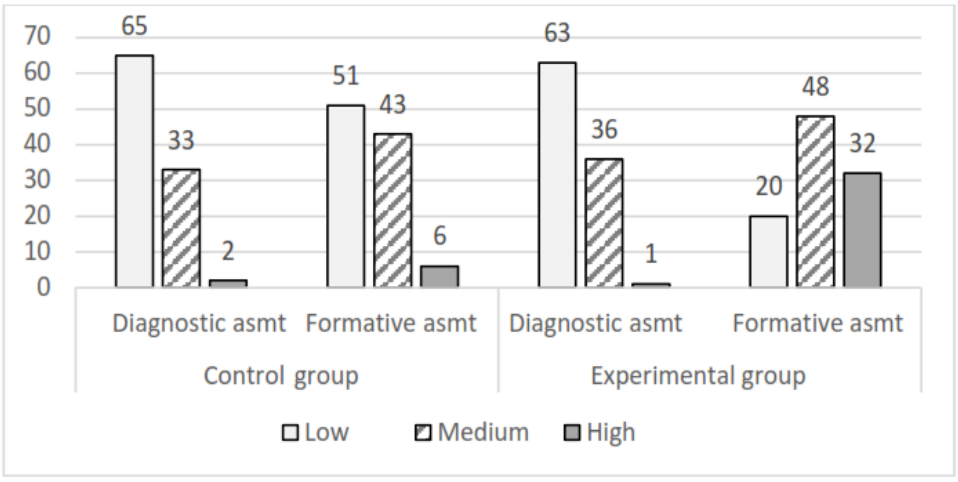

Figure 2. Comparing the changes of the level of acquisition of regulatory universal learning skills of primary school children based on the results of the conducted experiment (in %)

6.3. Changes in the acquisition levels of communicative universal learning actions of primary school children

The effectiveness of the acquisition of communicative universal learning actions of primary school children while teaching them robotics (see Figure 3) reasonably demonstrates not only the effectiveness of the conducted experiment and the successful realization of the process of teaching robotics, but also the adaptation processes resulting from the conducted experiment which allowed the students to express in a varying degree the ability to listen and participate in conversations and collective discussions of problems, integrate into a group of peers and collaborate with adults.

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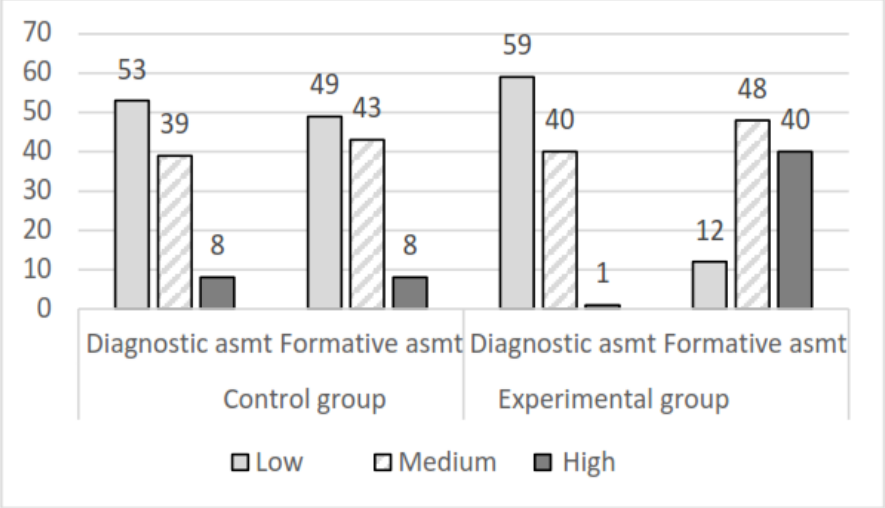

Figure 3. Comparing the changes in the acquisition levels of communicative universal learning actions of primary school children according to the conducted experiment (in %)

At the lowest level the student strictly follows the ready-made plan of educational collaboration with the teacher and the peers; at the medium level the student consciously chooses the goals, the functions of the participants, and the ways of interaction in the process of assembling robots; at the highest level the student fully under-stands and initiates collaboration in searching for and accumulating information, searching for and assessing alternative ways of testing and improving robots. The highest level of acquisition of communicative universal learning actions was achieved by 66 out of 163 students in the experimental group (40%), whereas in the control group it was achieved by only 4 students out of 49 (8%).

7. Conclusion

By contributing to the formation and development of universal educational actions, the teacher helps students with active figures in the educational process. According to the results of the control stage of the experiment the children of the experimental groups show considerable improvements in the level of acquisition of universal learning actions. This indicates that the stages, the mechanism and the algorithm of teaching universal learning actions to primary school children, which we have developed, are effective, as according to the formative assessment stage of the experiment the level of each of the universal learning actions (cognitive, regulative, and communicative) have improved considerably.

The research results are of practical importance for primary school teachers, heads of educational organizations, as well as for parents who are interested in the development of children's technical creativity.

References

Andreyev, D. V., & Izosimova, L. M. (2013). Apparatnoe i programmnoe obespechenie kursa robototekhniki na osnove tekhnologij LEGO [The hardware and software support of the course of robotics based on the LEGO technologies]. *Yaroslavl Pedagogical Newsletter: Natural sciences, 1*(3), 51-60.

Bayurova, V. R. (2019). Metody organizacii vneurochnoj deyatel'nosti pri izuchenii Lego Wedo 2.0 v nachal'noj shkole [Methods for organizing extracurricular activities when studying Lego Wedo 2.0

in primary school]. In L. L. Bosova & D. I. Pavlov (Eds.), *Actual problems of teaching methods of computer science and mathematics in modern schools*, (pp. 47-54). Moscow State Pedagogical University.

Budaev, D. D., Puchkov, K. V., & Baranov, S. E. (2019). Osobennosti vnedreniya kruzhka obrazovatel'noj robototekhniki v nachal'noj shkole [Features of the implementation of the educational robotics circle in primary school]. In A.A. Gorokhov (Eds.) *Modern materials, equipment and technology, (*pp. 318-320). Southwestern State University.

Budiyanto, C., Fitriyaningsih, R. N., Kamal, F., Ariyuana, R., & Efendi, A. (2020). Hands-on Learning In STEM: Revisiting Educational Robotics as a Learning Style Precursor. *Open Engineering*, *10*(1), 649-657. https://doi.org/10.1515/eng-2020-0071

Federal Educational Standard of Primary Secondary Education. (2009). The order of Ministry of Education and Science (adapted by on 6th October 2009, No 373). http://base.garant.ru/197127/

Ohnishi, Y., Honda, K., Nishioka, R., Mori, S., & Kawada, K. (2017). Robotics Programming Learning for Elementary and Junior High School Students. *Journal of robotics and mechatronics*, *29*(6), 992-998. https://doi.org/ 10.20965/jrm.2017.p0992

Papert, S. (1980). *Mindstorms: Children, Computers and Powerful Ideas*. Basic Books.

Papert, S. (1990). A Critique of Technocentrism in Thinking About the School of the Future. MIT Media Lab. *Epistemology and Learning Memo*, *2*. http://www.papert.org/articles/ACritiqueofTechnocentrism.html

Papert, S. (1993). *The Children's Machine: Rethinking School in the Age of the Computer*. Basic Books.

Papert, S. (1996). *The Connected Family. Bridging the Digital Generation Gap*. Longstreet Press.

Sorokin, S. S. (2017). Razvitie tekhnicheskih i logicheskih sposobnostej uchashchihsya posredstvom obrazovatel'noj robototekhniki [Developing technical and logical skills by means of educational robotics]. *Training experiment in education, 4*(84), 45-50.

Vegner, K. A. (2013). Vnedrenie osnov robototekhniki v sovremennoj shkole [Incorporating the basics of robotics in modern school]. *Vestnik of Yaroslav the Wise Novgorod State University, 74*(2), 17-19.