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Robotics in the international educational space: Integration and the experience

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Abstract

Nowadays robotics is one of promising avenues in the sphere of emerging technologies. In the teaching/learning environment we deal with educational robotics, which is a mixture of theory and practice, knowledge of computer technology, Mathematics and Physics. The two vectors are combined in educational robotics: the educational vector and the technological vector. As an academic discipline and an area of practical application, Robotics means a very broad spectrum of modern knowledge of diverse academic engineering specialties (fields of expertise). That means that Robotics is interdisciplinary in nature. The work provides an overview of the research aimed at studying Robot – Man interaction. Besides, the work considers some promising international cooperation between children from around the world on the development of robotics, and the experience and benefits gained from such cooperation. As an example of the international cooperation in the sphere of Robotics, the two countries, Russia and Kazakhstan, are considered. The article gives an example of the international cooperation of some educational centers, describes the experience of the work on robotics with children of various ages, and the cooperation of various schools working in this field in Kazakhstan and Russia. The working experience in the sphere of social robotics aimed at helping people has become a priority for the children from the interdisciplinary teams from Russia and Kazakhstan. Interaction and cooperation in the sphere of robotics was also used for introducing unconventional curricula, which included courses on robotic technologies as tools for considering social aspects of robotics and artificial intelligence.

Keywords Educational robotics · Social robotics · Motivation to study robotics

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1 Introduction

The development of the international cooperation is impossible without collaboration in the sphere of education. It is a way of interchanging knowledge based on international experience. A broad exchange of experience in the sphere of practical teaching activities can result in improving teaching process and delivery and exchange of knowledge, increased scientific cooperation and understanding among peoples. The integration of robotics in the international educational space expands the horizons of the activity in this area enriching theory and practice. The interaction of different scientific schools facilitates the deployment of students' personal educational trajectories.

A number of the articles dedicated to Robotics served as the basis for developing and introducing a learning platform in our study (Petre and Price 2004; Afari and Khine 2017). The authors give an idea of how robots interact with learners, and how the development of robotic systems influences the intellectual development of the human being. The overview of the provided scientific works proved to be rather clear and needed guidance for developing objectives and purpose of our study and its future prospects. In order to describe the importance of Robotics for education, we have studied a number of the articles about the interaction between robots and trainees, including those studying problems of developing robotic systems affecting human intellectual development.

Miller et al. (2008) in the article “Robots for Education” introduces the experience of using robotic systems; for example, learning tools across a variety of ages and in both formal and informal learning venues. The article provides an overview of robotic installations in informal learning spaces.

Some articles are dedicated to the installation of the developed platforms of teaching robotics. For example, the work “Platform for Teaching Mobile Robotics” by Fabregas et al. (2016) describes the development of a motivating and innovative multi-robot formation control platform for laboratory experiments with mobile robots. The platform is composed of two components: a simulator and an environment to experiment with low cost wheeled mobile robots. This paper describes the components of the Robots Formation Control Platform (RFCP); a web based tool for simulation and real experimentation with mobile robots with pedagogical purposes.

Filippov et al. (2017) in the article “Robotics Education in Saint Petersburg Secondary School” describe the Robotics Center, the unique place that has succeeded to create from the very beginning a complex education system, that includes Robotics courses for schoolchildren (Basic Robotics, Electronics, Applied Mechanics and Programming), competitions and festivals, camps, courses for teachers and other activities that join together children, their parents, teachers and enthusiasts, who are keen on robotics.

The work “Robotics Education for Children at Secondary School Level and Above” by Stone and Farkhatdinov (2017) describes the experience of teaching Robotics to children at secondary school level. A set of exercises was designed and evaluated. Some exercises were designed for teaching robotic systems, basic programming and control concepts, and the tasks included learning important mathematical and physical science definitions. The proposed robotics exercises were introduced to the curriculum of the London School of Mathematics and Programming, and preliminary teaching and

learning outcomes showed that the majority of the proposed robotics exercises were attractive to children independently of their difficulty.

The article “Design and Impact of a Teacher Training Course, and Attitude Change Concerning Educational Robotics” is dedicated to the role and importance of educational robotics (ER) for teachers and teaching process on a whole. The article authors, Castro et al. (2018) tried to present a training course on ER (Edu.Ro.Co.), grounded in pedagogical insights, and to discuss the results of the course and teachers’ opinion about ER in terms of: (i) teachers’ attitudes and perceptions of using ER; (ii) the potential impact of ER on students’ key competences for lifelong learning; and (iii) strengths and weaknesses of ER.

Kopcha et al. (2017) in the article “Developing an Integrative STEM Curriculum for Robotics Education Through Educational Design Research” also study problems of educational robotics in the sphere of educational design. They present an integrative standards-based STEM curriculum that uses robots to develop students’ computational thinking. The authors detail the first mesocycle of the educational design research project (EDR) in which a robust theoretical framework was created to support the development of a 2-week series of robotics lessons.

Besides, Ioannou and Makridou (2018a, b) study the possible use of STEM in educational robotics. In their work “Exploring the Potentials of Educational Robotics in the Development of Computational Thinking: A Summary of Current Research and Practical Proposal for Future Work” they consider educational robotics as a useful supporting tool for the development of cognitive skills, including Computational Thinking (CT), for students of all ages. This study reviews published literature at the intersection of CT and educational robotics, particularly focused on the use of educational robotics for advancing students’ CT skills in K-12. The authors consider that a practical framework for the development of CT via robotics is next in demand, so as instructional designers and educators can implement it consistently and at scale.

Rihtaršič et al. (2016) in “Experiential Learning of Electronics Subject Matter in Middle School Robotics Courses” write about the necessity of studying electronics and electrical engineering in the course of Robotics. The authors tried to investigate whether the experiential learning of electronics subject matter was effective in the middle school open learning of robotics.

The effects of robotics training on students’ creativity and learning in physics have been considered by Alireza Badeleh (2019). In his study, the effects of robotics training on students’ creativity and learning physics were investigated. When investigating the author used a test of 10 learning points and a package of training on robotic constructs in physics. The results of Alireza Badeleh’s study indicated that Robotics training influenced and improved creativity and learning in physics among the participants.

Armesto et al. (2016) in the work “Low-cost Printable Robots in Education” write about using a 3D-printer when creating robots and robotic tools. In their work the authors describe free printable robot models, also known as printbots which can be used for research, as well as for other educational and non-commercial purposes.

Wang and Huang (2019) in the article “Virtual Plate Based Controlling Strategy of Toy Play for Robot’s Communication Development in JA Space” study a toy play controlling strategy in JA space based on a virtual plate with a serial robot arm, which has five degrees of freedom (5-DoF). The work is built on the investigations, carried out by Kerimbayev (2016). The experience of virtual learning is presented in the work

by the result of the connection with teaching robotics in the virtual educational space. Virtual communication of the children dealing with robotics together with the experience exchange of those managing study groups and centers in Russia and Kazakhstan improves the collaboration of the representatives of the scientific community as parts of the integrated network of teaching/learning Robotics.

Pierre Dillenbourg (2016) presents the evolution of research in digital education. He considers this evolution identifying several trends. Physical and digital, according to the author, are now increasingly interacting thanks to a virtual environment.

The articles “Between the Social and the Technical: Negotiation of Human-Centered Robotics Design in a Middle School Classroom” (Gomoll et al. 2018), “Socially Responsible Engineering Education Through Assistive Robotics Projects: The RoboWaiter Competition” (Ahlgren and Verner 2013), “Adaptive Robotic Tutors that Support Self-Regulated Learning: A Longer-Term Investigation with Primary School Children” (Jones and Castellano 2018) are dedicated to the investigations of social robotics in the educational space.

The cooperation of scientific schools from different countries contributes not only to the cooperation at the state or regional level but also at the personal level, for it contributes to the development and improvement of students’ personal educational trajectories. The authors provide with the experience of the communication between school students and teachers and prospects for further cooperation in the sphere of developing robotics and virtual learning.

The distributed mixed method for today used in training and consideration of its aspects and criteria for assessing the quality of research is presented in the works of Clark and Creswell (2008). The aforementioned works of researchers, as well as the work “Mixed Methods” (Kuckartz 2014), on international interactive interaction between students and teachers of universities in Kazakhstan and Slovakia (Kerimbayev et al. 2020), served as the basis for determining the purpose of this article.

The aim of this article is to document experience of international cooperation of Russia’s and Kazakhstan’s educational centers. Besides, we wish to share our experience, which we have gained for several years in the sphere of educational Robotics.

2 Methodology

2.1 Analysis

This chapter of the study introduces the analyses of the development of education in the sphere of robotics in Russia and Kazakhstan, and its modern conditions. The results of the work that has been done over many years and include interviews with some experts, surveys, visits to some institutions, competitions and conferences, study of the normative base, political documents and curricula, are summarized here.

Robotics and robotization are strongly developed all over the world, including such countries as Russia and Kazakhstan. Robotics is introduced at schools, and industrial robots are increasingly used in enterprises. Earlier in our study, we had experience of cooperation in the sphere of education between universities of Russia and Kazakhstan. The introduction of such disciplines as Robotic systems and Robotics into university

programs became the basis for establishing centers of robotic training for infants and children.

Within a relatively short period of time Robotics, which was taught only at universities, became an integral part of school curricula; and was even introduced to nursery schools. As the proper equipment become more available, the relevant teaching methods and training programs are extended. There is also an increasing interest of parents in studying Robotics by their children.

We have interviewed a lot of school and university teachers dealing with the problem of introducing Robotics into preschool and school curricula and school learning process. We wondered what teachers and scientists thought of introducing Robotics into learning process, which subjects had to be included in Robotics lessons, in what grades and how many times a week Robotics had to be taught.

According to the results of all the respondents interviewed we get the following figures: Introducing Robotics lessons within curriculum – 46%, Introducing Robotics lessons as extracurricular activity – 22%, Teaching Robotics at Computer science lessons – 14%, Teaching Robotics at Technology subject lessons – 11%, Robotics should be taught out of school – 7%, There is no need for learning Robotics – 0%.

The results show that learning Robotics is very important. Nowadays in many countries Robotics is introduced into school curricula as a compulsory subject or as extracurricular activities. Teaching Robotics is positioned in the context of teaching several disciplines. Robotics can be taught when teaching such disciplines as Physics, Computer science, and Technology. Therefore, Robotics is the integral part of several disciplines.

However, it should be recognized that at present many schools lack Robotics teachers. In such a situation, educational centers can provide us with the possibility to learn Robotics. Educational centers also offer courses on studying Robotics for elementary and secondary school children.

For example, in Kazakhstan over 20,000 schoolchildren engage in this interesting and prospective field. The educational centers are equipped with the newest sets on robotics, using which one can put into practice the most challenging and courageous projects: to model and program real robots with multiple functions and abilities.

The study considers the development of theoretical Robotics as a self-organizing, evolving, human size system based on interdisciplinary analysis. The methodology was compound of the problems of the study: to determine the place of educational Robotics in connection with the social and cultural aspect; to reveal the relevance and the level of developing learning, cognitive and personal motivation of junior school students in the process of studying Robotics. In the work we applied the method of imaginary experiment and its materialization on the created robotic models. In general, the study is considered in terms of HRI problems (Human-Robot interaction). An imaginary experiment helps students create objects in their imagination, then realize those using mechanical tools and details, and create real mechanisms.

2.2 Four-stage cycle

When considering the level of pupils' motivation, the study is based on the model of learning developed by Kolb (1984). The study includes a four-stage cycle:

- 1) It is based on child's real experience;
- 2) Mental observation;
- 3) Abstract conceptualization;
- 4) Active experimenting.

Depending on a child's way of thinking, we choose a preferable for him/her study style: activity-oriented (oriented on knowledge application and the tendency to learn through practical situations) and analytical (oriented on logical analysis and theoretical reasoning). (Fig. 1).

Here are some statistical data on qualitative and quantitative ratio of the children learning Robotics provided by Russian National Research University (Table 1).

In 2016 in the Republic of Kazakhstan, the curricula of elective courses on Robotics were developed: the first level course for the 3, 4 and 6 grades and the second level course for 7, 8 and 9 grades respectively.

In 2019, the number of robotics study groups was 1626, the number of children engaged in study groups was 33,000, and the number of robotics classrooms was 2001. The number of teachers trained in Robotics is growing every year. In 2017, 5000 Computer science teachers improved their qualifications; in 2018, 50 trainers and 1500 Robotics teachers were trained.

2.3 Study participants

One of the problems Russia's and Kazakhstan's Robotics education face is adaptation of the curricula to the modern world level of Robotics development. The second important problem is a poor collaboration for exchanging practices and programs.

The prospects of integration of Robotics into the education system for a country are quite obvious. Robotics is an applied science dealing with the development of automated engineering systems. Robotics is one of the most important areas of scientific and technological progress, in which problems of mechanics and new technology meet with problems of artificial intelligence.

Some problems of extensive cooperation with our partners in Russia are connected with such difficulties as necessity to cover great distances and spend a lot of time. A closer communication between learners takes place during meeting at international contests and Olympiads. At other times, a lack of "live" communication is overcome through using information technology in the form of webinars and videoconferences.

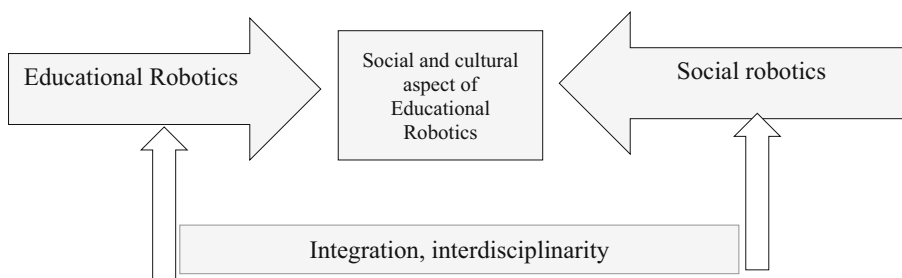


Fig. 1 Integration of educational and social robotics

Table 1 Statistics on the qualitative and quantitative ratio

Year	2013	2017	December 2018		
Ratio	5,9%	6,8%	14,2%		
Age	5–6 years old	10–13 years old	14 and over		
Ratio	9%	18,9%	6%		
Gender	Boys	Girls			
Ratio	79%	21%			
School type	General education	Grammar school, lyceum	Schools specializing in some subjects		
Ratio	14%	18,3%	20,6%		
Parents' education	General education	Upper secondary education	Secondary-special education	Higher education	Academic degree
Ratio	6%	10%	12%	14,6%	18,1%
Accessibility	Free of charge lessons		Fee-based courses		
Ratio	62%		38%		

Studying Robotics paves the way to socialization of pupils and provides an opportunity to educate them technically and continuously, and learning using LEGO-sets and other robotic constructors of computer technology is pupils' way to modern future-oriented professions and a successful life in the information society. It is certain that dealing with robotics does not mean that all the children will be willing to become programmers or robot designers, engineers or researchers. In particular, these lessons are aimed at general scientific training of schoolchildren, at developing their thinking, logic, mathematical abilities, and research skills.

The children who begin studying a subject think of the opportunity to combine their studies with fascinating games rather than of future prospects. It is pleasant to learn fundamentals of a new subject using tutorials so similar to children's building blocks. Boys and girls are so much interested in the process that they do not want to leave their robots. It must be said that without those specific "bricks" the robots could look quite "industrial", let alone the functions, which "are taught" to them by their young designers. The assembled mechanisms are equipped with real sensors, they are programmed and have most of the characteristics specific to real robots, which are operated in industry.

Robotics enables children to put into practice their dreams and ideas. Not all of these children will deal with robotics in the future, but their understanding computer technology and gaining technological skills will help them in their future professions.

Children gain knowledge and primary skills of such work in robotics study groups. These study groups are organized in different educational centers and schools where children study. In the study groups children study microchips and fundamentals of designing and programming. Usually they begin with creating their own gaming devices. In such a way the children develop interest in the process of designing. Besides, school students gain more knowledge of physics, mechanics, 3D design, projecting and programming. The activities in study groups develop logic and creative thinking, attention and patience. When working with a construction kit and its parts

primary school children develop their fine motor skills. Robotics study groups help a child prepare for coping with the curriculum.

Beginning with basic designing at primary school, children learn to create complicated technological systems late in their school-age years. The basic knowledge and designing skills developed at primary school is an integral part of further robotics skills development. A child's engineering skills under favorable conditions can bring great discoveries in the future. The development of primary school children's engineering skills continues from the targeted development of their sensory-motor skills and spatial and creative thinking to the development of their basic individual abilities in the area of engineering creativity in senior classes: observation in the sphere of technical devices, combinatory skills, engineering thinking, and programming skills.

Curricula on Robotics enable school children not only to gain a new knowledge but also to put into practice their ideas. Moreover, teachers do not limit any flight of pupils' imagination. Not all the pupils would like to deal with robotics in their future. Some of them are going to be doctors, some of them would like to be scientists, others dream of being cosmonauts. However, one cannot acquire Robotics without knowing Computer Technology, Mathematics, and Physics. Children learn to make decisions, to accept lapses and failures, to concentrate on specific problems. And this will be useful for any profession. On the other side, by the time when these children grow up it is unlikely that there will be spheres of human activities not involving robots.

The described activities contributed to children's understanding and respecting norms of behavior, communication and shared values of the human society; to motivation, creativity and a will to succeed.

Children's participation in competitions, travelling outside towns, cities and regions make it possible to communicate with their social partners. The social partners, with whom the centre of training Robotics cooperates, are presented in the following chart. (Fig. 2).

The study has shown that learning is successful when a child is involved in the process of creating an important and meaningful product. It is important that when designing and programming a child develops his/her knowledge, while the teacher helps him/her just consulting. At the beginning the software should have a clear and easy interface in order to help the child understand so as to develop from a beginner into a skilled user later. Studying Robotics helped the school children extend their knowledge of the world around them and the tech world; learn to resolve creative

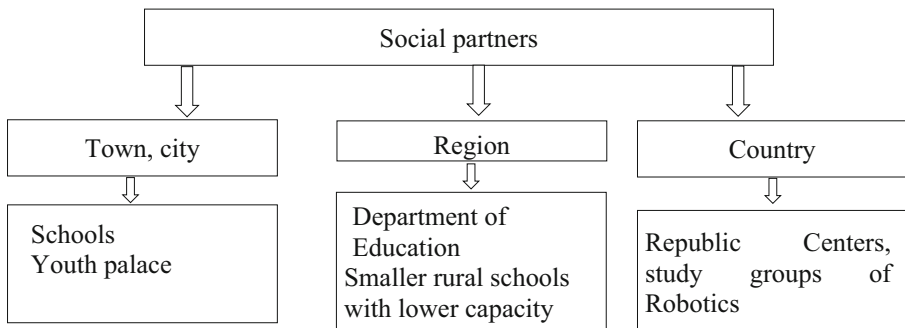


Fig. 2 Chart of interaction with the society

extraordinary situations in practice when designing and modeling objects in our reality; develop their communicative abilities, the abilities to work in groups, to professionally present the results of their activities, to defend their point of view; create complete projects using acquired instrumental computer environments.

3 Results

This chapter describes the content of the innovational experience of Russia and Kazakhstan, forms and methods of organizing teaching fundamentals of Robotics as an interdisciplinary course of introduction of Robotics to a school educational space.

During over ten years, in the Russian city Novokuznetsk, there has been “Talos”, Robotics Academy (<http://edurobots.ru/kruzhok/akademiya-robototexniki-talos-novokuzneck>), which exists and successfully operates under the leadership of Anatoly Kovtun. They call themselves “Social Gentlemen’s club”, though the results of the activities on creating robots are represented at the professional level. After requiring fundamentals of projecting, designing and programming LEGO robotic systems (robots), which lasts first 3–4 months, “academicians” practically independently prepare for different competitions: Olympiads and contests. Each of them prepares his or her own individual design of a robot according to his or her ideas, but after discussing rules and requirements of the specific event.

All the pupils are trained for competitions on robotics. The pupils choose some kind of competitions or a specific kind of contests and begin preparing for it. They develop and program a robot in order to participate in this kind of competitions.

In order to understand motivation of the children who study Robotics, a questionnaire was carried out. The questionnaire was based on the training model developed by D. Kolb (1984) and the typology of learning motives, “Motivation Ladder” (Fetiskin et al. 2002) (Table 2).

When carrying out questionnaires it was necessary to take into account the fact that parents also take interest in robotics contacting the training and educational centers providing supplementary education to schoolchildren. Therefore, it was important for

Table 2 The results of the diagnostic investigation of the pupils using the “Motivation Ladder” methods adapted to the subject of the study

№	Motives	Characteristics	
		External (social)	Internal (cognitive)
1	I study Robotics because I would like to learn		
2	I study Robotics because I like designing		
3	I study Robotics because a modern person should be able to create something new		
4	I study Robotics because it is informative and it broadens my outlook		
5	I study Robotics because I would like to design something useful for people when I grow up		
6	I study Robotics because I would like to please my parents		
7	I study Robotics because everybody studies it		
8	I study Robotics in order to be praised by my teacher		

us to find out whether the children themselves were interested in studying Robotics or it was just their parents' wish.

Let us see which motives take the first four lines in the hierarchy. If they are two social and two cognitive, then we conclude that the combination is harmonious. If they are three or four motives of the same type, then we conclude that this type of learning motives dominates. (Tables 3 and 4, Figs. 3 and 4).

The comparative characteristics of the children studying Robotics in Russia and Kazakhstan showed predominance of social motives.

We have monitored students' motivation to study robotics. When comparing the academic year 2017/18 and the school year 2018/19, the monitoring results showed an increase in motivation to study robotics. The results of the input and output monitoring of students' motivation to study robotics are shown in Fig. 5.

Thus, we can observe changes in secondary school children's motivation, their personal motives for studying Robotics.

One can observe that those children who took part in Robotics study groups changed their activity methods; besides, their cognitive abilities and intellectual activity changed, as well. The children proceeded from just observing and gaining theoretical knowledge to abstracting, to building an image mentally and getting a practical result. It often took place in the form of an "insight", that is an unexpected solution of the idea. This experiment is presented in the next chapter irrespective of the children's homeland and nationality.

When developing robots schoolchildren gain ideas, which adults cannot imagine. For example, Gleb Korneyev, the sixth-form pupil from a lyceum of mathematics (from Novokuznetsk city) suggested some improvements in the design of a robot made of LEGO set for competitions in covering the whole route, which is complemented by an alarm system composed of the parts missing in the set. For the emergence and realization of this idea one should know fundamentals of electrical engineering and electronics, ability to assemble and solder electronic components.

Stages of building any robotic system (further we call it a "robot") include the following:

1. Idea; that is defining goals and objectives, which a robot should carry out.
2. Projecting; that is determining and choosing necessary controlled input parameters and possible control actions, selecting the components: sensors, performing

Table 3 Hierarchy of the motives of the children studying Robotics in Russia

Hierarchy of the motive										
Social	Rank								Points	Total
	Internal	0	0	1	0	1	1	1	4 (10%)	28 (60%)
	External	4	4	3	4	3	3	3	24 (50%)	
Personal	Internal	3	2	2	4	3			14 (28%)	20 (40%)
	External	1	2	2	0	1			6 (12%)	
Bcero:									48 (100%)	48 (100%)

Table 4 Hierarchy of the motives of the children studying Robotics in Kazakhstan

Hierarchy of the motives									
Social	Rank							Points	Total
	Internal	1	1	0	0	1	0	3 (7,5%)	24 (57,5%)
	External	3	3	4	4	3	4	21 (50%)	
Personal	Internal	3	3	3	4			13 (35%)	16 (42,5)
	External	1	1	1	0			3 (7,5%)	
Bcero:								40 (100%)	40 (100%)

devices and other items, elaborating different systems (power system, control system, etc.)

3. Designing; that is developing all the junctions of a robot in details, projecting, designing and manufacturing original 3D elements.
4. Manufacturing junctions, designing, testing.
5. Programming a robot.
6. Debugging and setting the whole system, testing the resulting robot, verification of the compliance with the idea.

Stages can be detailed, changed, but the main set of actions in general and the very sequence of the stages remain as described above.

Let us consider another aspect, the form of communication, by which new knowledge resulting in the development of new competences can be delivered. If a pupil is bored at a lesson then that is a teacher who is to blame. It is a common opinion. In order to make a pupil interested in a lesson, the lesson should contain some elements of novelty, and the pupil should have an opportunity to prove himself! A possibility to use a new communication technology reducing “time and distance” can help in this situation. Nowadays, more and more various integrative teaching methods are used, in which the convergence of different fields of knowledge is combined with the development of STEM system disciplines at different levels of learning, from elementary and intermediate to advanced ones.

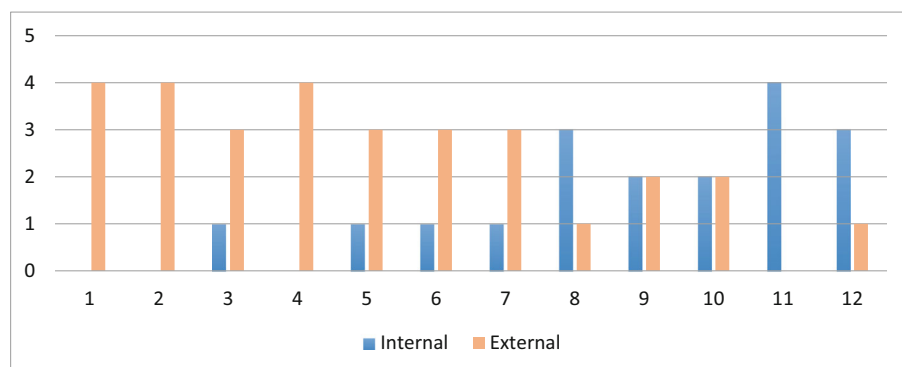


Fig. 3 Hierarchy of the motives of the children studying Robotics in Russia

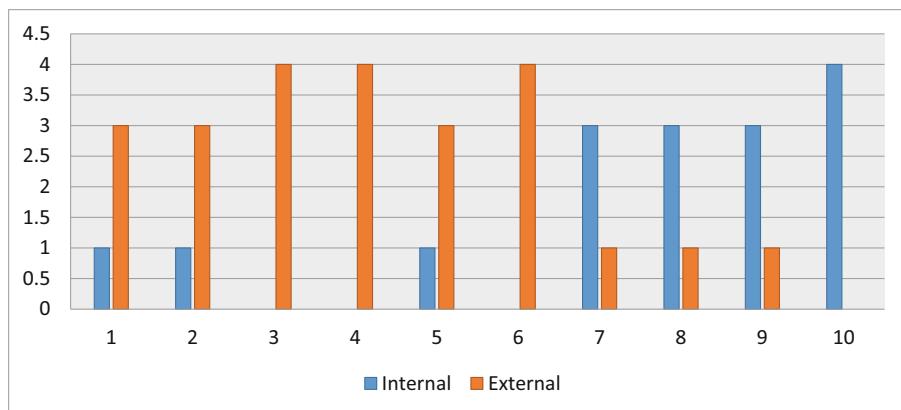


Fig. 4 Hierarchy of the motives of the children studying Robotics in Kazakhstan

The combination of these factors – novelty and attention to a pupil – has a multiplicative effect. A teacher can use even some unusual combinations of the approaches, which cannot be found in any of teaching methods. Let us imagine the following situation. Pupils from different age groups (joined in small groups consisting of the pupils of nearly the same age and the same level of understanding, which are formed by a coordinator) from secondary schools of the same town or city are put in one of the best university robotics laboratory where together with some enthusiastic university students from the faculty of information technology they discuss prospects of their own development and the development of robots! In such a situation, many different subjects are discussed, some skills not listed in any of curricula are developed, for example, skills of developing extraordinary robots, which do not even exist, robots for using in augmented reality, and even skills of developing systems of artificial intelligence (AI), which is nearly upon us! Moreover, problems of developing, learning and applying artificial neural networks (ANN) to today's robots are discussed. 10 year old children speaking of AI and ANN, can you believe it?! Such kind of meetings,

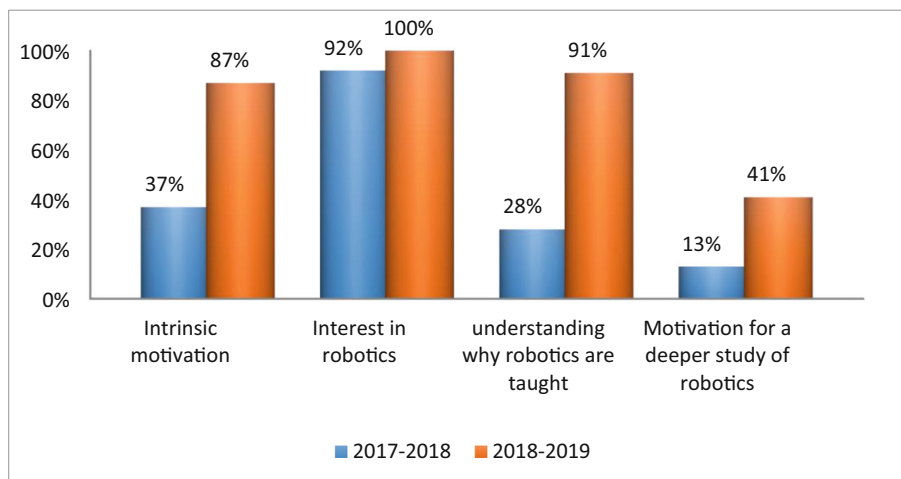


Fig. 5 Indicators of motivation for studying Robotics. Input and output monitoring

meetings of schoolchildren and university students, are not ad hoc activities for “academicians” from “Tallos” Robotics Academy. They hold such meetings as regular weekly sessions. A special atmosphere of such meetings makes it easier for today’s schoolchildren ask questions to students who themselves were at school not long ago and who can easily understand them.

The fact that “pupils–academicians” regularly participate in various robotics competitions and Olympiads, sometimes together with the students who help them prepare, is very important. Besides, a particular attention of mass media to the participants of competitions is also a factor, which stimulates children’s interest in studying Robotics. (Fig. 6).

The “Academy” pupils, Artem Prokhorov, Maxim Belarev, Gleb Korneyev, Daniil Bezrukikh, and Svyatoslav Lyubimov, developed an electronic guide for blind people for moving in some closed dark areas where the use of lanterns is not advised. The material used is absolutely safe, as it consists of blocks of the most popular brand, LEGO. (Fig. 7).

The rationality of a structural solution is defined by compactness of the arrangement of all necessary sensors, fully hidden (without obstructing access to buttons) stowage of wires. (Fig. 8).

The basis for the movement in every direction is some technological problem, while solving which a pupil develops in the cognitive and activity-oriented sphere. On the one hand, it consists of the desire to gain the theoretical knowledge necessary for solving a problem using achievements of variety of sciences; on the other hand, as a young developer the pupil can focus on presenting a solution to the technological problem in the final product.



Fig. 6 Pupils of the Russian “Robotics Academy”



Fig. 7 Arranging of sensors and the unit for controlling the first prototype of the electronic guide for blind people

In order to solve a specific problem, in particular, to develop, design and build a robot it is necessary to integrate cognitive achievements of a number of disciplines in one process. Teaching fundamentals of Robotics and Programming at Kazakhstan's secondary schools has yielded positive results (Fig. 9). The interest in building robots results in the increase of the motivation to study Robotics. For example, Ainar N., a pupil of the study group who goes to some Almaty school, works at building a robot-guide for disabled people.

The work of the pupils, their joint activities on designing robots for different goals, their participation in competitions and Olympiads contributed to keeping them motivated. The focus on “competitive robotics” had a double effect: the pupils' continued interest in combination with great emotional needs – “I can do this; I can do it better...” A continuous communication with other pupils and even university students is another positive factor. Today's students are yesterday's schoolchildren; they are almost of the same age. This fact stimulates even more.

Educational robotics is the tool of the subject, which provides a great impact on the development of pupils' speech and cognitive processes (sensor development, the development of thinking, attention, memory, and imagination), including the emotional sphere and creative abilities. Educational robotics enables to create dynamic schemes at lessons, which reflect some forms of phenomena, and to make the demonstration of experiments bright, colorful and more visual. Besides, educational robotics makes it possible to increase the number of practical works, demonstrations and summarizing lessons.

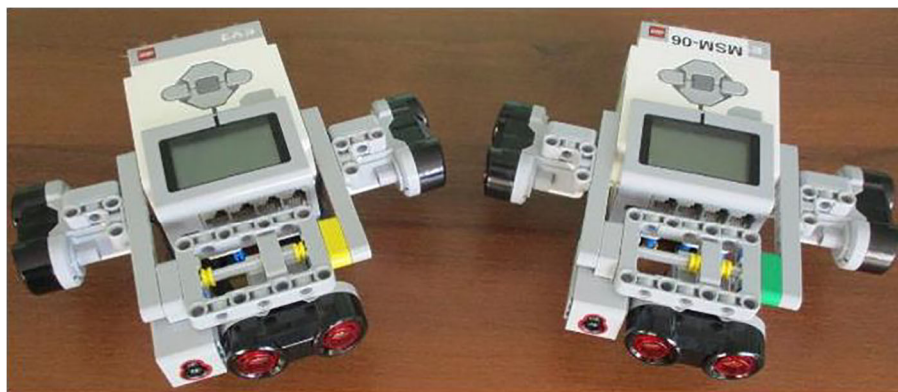


Fig. 8 “Electronic guide for blind men” developed by the pupils of Robotic Academy



Fig. 9 Study of fundamentals of Robotic in Kazakhstan's schools

4 Conclusion

This study is dedicated to considering the problem of educational Robotics. The work at this article was aimed at sharing the experience gained for several years in the sphere of educational Robotics. We tried to determine the condition and development of Robotics in such countries as Russia and Kazakhstan. The long-standing collaboration between the educational centers of Kazakhstan and Russia enabled young partners from these two countries to share experiences and collaborate. Modern technologies have created a window of opportunity to communicate for teenagers despite thousands of kilometers distances, to share their achievements in the sphere of building robots and robotic constructions. We were interested in observing the level of motivation to study Robotics and the development of motivation as the students went into further detail of the theory and practice of robot design. We were happy to see the teenagers' growing interest and fascination when they built robots. Heterogeneous groups have also had a positive effect: elder students helped younger students, explained to them indistinct things. Besides indicating the level of the children's knowledge in the sphere of Robotics, their achievements that we described above also demonstrate their interest and fascination in Robotics, which in the future can even turn from a hobby into their profession and lifework.

The communication and collaboration of the children from both countries who can communicate using the same language, provided an opportunity to improve learning process, to transfer and share knowledge, and to have leisure activities in their spare time. Healthy competition drives the children's desire to get a new perspective when solving different problems, to think outside the box, and to be creative.

The study has proved that the experience of scientific teaching collaboration and exchange of the knowledge and achievements of children from different countries lead to understanding most phenomena and processes, teach them friendship and tolerance in modern society and in the world.

5 Discussion

The study is dedicated to the problem of cooperation of the two countries in the sphere of Robotics. Integration in this sphere enabled to realize an interactive engagement of the participants, school children and the children who attended classes at educational centers on studying Robotics. These children developed their abilities and motivation, and they felt satisfied with their own achievements in creating robots.

Robotics in the sphere of education is more important and prospective than we could imagine. Establishing links among pupils who study fundamentals of Robotics in different forms, and professionalizing them is the main objective of the work on integration and experience exchange between Russia and Kazakhstan.

Since 2017 the children from “The Academy”, Novokuznetsk city (Russia), and from Kazakhstan have communicated virtually using the portal “Virtual learning”. Thanks to the modern communication technology, children have an opportunity to communicate online and share their success stories and achievements. Organized joint competitions and master classes enrich children’s knowledge, abilities and skills, broaden their communication and teach them to cooperate. While carrying out our research we had an opportunity to observe what a positive emotional effect Robotics lessons had on the children: their mood improved, shy and introverted children began showing themselves while learning to communicate with others children. We consider that this important psychological and emotional factor requires further studies.

An international factor, useful for both parties, is a new knowledge and more importantly new friends, the friendship among young people and the friendship between the two counties.

The results obtained are channeling towards further cooperation and integration in the sphere of Robotics among children from different countries.

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