

Forming Research Competence and Engineering Thinking of School Students by Means of Educational Robotics

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ABSTRACT

The relevance of this research is defined by a possibility of increase in efficiency of school students' research competence formation by means of robotics within fixed and extracurricular activities and additional education. The problem of a research is defined by a contradiction between widespread introduction of robotics in modern society life and insufficient techniques of studying robotics in order to key competences formation. The objective of this research is studying the didactic potential of robotics for school students' research competence formation and to offer the methodical approach to the organization of classes in robotics on the basis of research tasks and research projects. The article presents methods of studying robotics, the use of which helps to form the skills of independent research activities, as well as the ability to apply modern technology in solving practical problems. The article can be used by teachers of educational organizations and the organizations of additional education in preparation for robotics classes (in fixed and in extracurricular activities, in additional education); in analysis of teaching robotics methods, teachers of pedagogical universities to present the methodology of teaching robotics to the students, teaching staff of institutions of additional professional education in preparation for training courses.

Keywords: robotics, research competence, system and activity approach, universal educational actions, metasubject competences

INTRODUCTION

Relevance of a Problem

New time demands new specialists. Now specialist must be able to work under pressure, to handle large amounts of information, possess critical thinking skills, ICT competencies, to be creative, proactive, independent in decision-making (Galushkin, 2018; Gimaliev et al., 2018; Potapova et al., 2018; Skurikhina, 2017a, 2017b). And the requirements will grow more and more. An attempt to describe new professions, their characteristics, the professional competences was made by "Atlas of new professions", which contains a description of the future jobs. On the basis of this Atlas analysis, we can conclude that the specialists of the future will be useful to ICT competencies (and to have more high requirements to the skills of designing and programming, formation of algorithmic thinking), ability to work in team, to manage projects, conduct research.

The analysis of tendencies of IT sphere development (Akishina et al., 2017; Kryukova et al., 2017; Mutavchi et al., 2018; Skurikhina, 2017a, 2017b) shows that the companies impose rather serious requirements to IT specialists: to be able to carry out the business processes analysis, to develop the strategy of IT department development, to

Contribution of this paper to the literature

- Successful practices of carrying out researches, using of research tasks on classes of robotics are investigated.
- The concrete technique of carrying out a research on robotics, concrete materials for formation of research competence is offered.
- Examples of research tasks and an algorithm of phased transition from work under the leadership of the teacher to independent research are described.
- Features of research competence formation during studying the robotics and difficulties which teachers can face are distinguished.
- The impact of research competence formation by means of robotics in engineering thinking formation and early vocational guidance for engineering professions is analyzed.
- Features of a technique of preparation and carrying out the robotics lessons directed to research competence and engineering thinking formation, problems of assessment of research competence formation are presented.

carry out modeling, reengineering, to conduct the scientific and practice-oriented researches. In addition, the modern business is characterized by rapid and unpredictable changes in the external environment and the need to make decisions in a short time. In fact, the professional of the future is not only executor who works hard according to the algorithms in well-defined conditions. The modern specialist is the researcher, who must be able to work with information in a changing and uncertain situation, ready to self-development and self-education (Skurikhina, 2017a, 2017b). In order to be able to make decisions in a fast-changing, multi-criteria environment in the short terms, modern specialist should possess certain competencies, including project and research competencies (Hutmacher, 1996).

All this causes relevance of research competence development in future experts. Questions of school students key competences formation are considered by many scientists: Mulder (2012), Spencer (2003a, 2003b), Van der Bergh (2017), Bolotov (2003), Borisov (2002), Vtorina (2003), Dakhin (2004), Ivanova (2004), Osmolovskaya (2006), Raven (2002), Ryzhakov (1999), Savenkov (2004), Khutorskoy (2003).

The competence assumes the formed ability and readiness of the expert to solve the professional problems on the basis of the available theoretical knowledge, abilities, skills and experience of practical activities (Ivanova, 2004; Zimnyaya, 2006).

Special attention is paid to the questions of practical use of the available theoretical knowledge, their continuous updating (ability to study during all life), differentiations of scientific knowledge to branch scientific knowledge, possibilities of transformation of the resources into a certain product (Mulder, 2012; Spencer, 2003b).

The questions of research abilities development and research competence formation were considered in works of such authors as Davidson and Palermo (2017), Hyusen and Tuyman (1991), Artsev (2005), Vorobyeva (2013), Zaprudsky (2016), Znamenskaya (2006), Leontovich (1999, 2006), Mukhina (2006), Obukhov (1999, 2006), Skurikhina (2015, 2017a, 2017b), Firsova (2003), Hudin (2006), Chudov (2005), Shumakova (2006).

On the basis of the analysis of these authors' works one can conclude that the research competence of a student is the ability and readiness to organize and conduct effective educational research (and further research work), the ability and readiness to self-education and self-improvement throughout life, the integration of research actions into a coherent whole, defining the dynamics of the transition from performing to creative and constructive activities.

Very important aspect which is noted by all scientists is that the research competence is the whole complex of the competences interconnected among themselves which include both theoretical knowledge, and practical skills and also experience of practical activities (experience of the use of existing knowledge and skills). It is necessary for school students both in the course of training, and in future professional activity.

The research competence is the whole complex of competences. Formation the research competence of the students involves the following aspects (Vorobyeva, 2013):

- 1) ability to identify and solve research problems;
- 2) to conduct search, processing, systematization and synthesis of scientific information;
- 3) to create significant products of research activity;
- 4) readiness and ability to build effective scientific communication.

Formation of research competence assumes assimilation of knowledge, development of abilities and receiving experience of carrying out educational researches. In the future this experience can be transferred to the process of research in practical and scientific activities. The research assumes passing of certain stages (Chudov, 2005; Vorobyeva, 2013; Zimnyaya, 2001):

1. The preparatory stage assuming definition of a problem, statement of the purposes and research problems, formulation of a working hypothesis, scheduling.
2. The research, including finding information on the topic of research, analysis and evaluation of obtained information, collection and processing of empirical material, synthesis and analysis of findings, formulation of conclusions.
3. The evaluation stage which contains assessment of the results, correlation of results to stated purposes, the presentation of results, a reflection and encouragement of pupils is carried out.

The incorporation of educational research into the educational process fully complies with the requirements of Federal state educational standards (Petunin, 2003), because the skillful organization of educational research allows us to develop all kinds of universal educational activities: cognitive (problem definition, information search, analysis, synthesis), regulatory (planning work, monitoring of results, correction), communication (organization communication in the group, presentation of the results of work) and personal (self-determination) (Pivovarov, 2014; Skurikhina, 2016).

Of course, the pupil can't master at once all process of carrying out a research therefore there are different levels of research method realization (Vorobyeva, 2013):

- the teacher identifies a problem and plans strategy and tactics of decision which the pupil should find independently;
- the teacher identifies a problem; pupils look for the decision independently (collective search is allowed);
- definition of the problem, finding research methods and development of the decision is made by pupils independently.

As noted by the supporters of research training, the training process should ideally simulate the process of scientific research, the search for new knowledge.

Robotics as the young and perspective direction, is completely focused on the solution of a problem of research competence formation. It is connected with the fact that the majority of tasks which are set for the pupils in robotics classes - uncommon and have no ready decision. Questions of introduction of robotics in educational process are considered in works of such authors as Alimisis (2013), Bers et al. (2002), Surmann, Nukhter and Gertsberg (2003), Alexandrov (2015), Apacheva (2014), Boyarkina (2013), Dakhin (2015), Dyakova (2013), Ershov (2013), Koposov (2013), Maksimov (2011), Kuzmina (2016).

So, all specified authors note that robotics assumes the solution of the practice-oriented tasks. At the same time it is important to understand that different students can get different results. In addition, to solve this problem you need to get some knowledge, to conduct an experiment, analyze the results, draw conclusions. The teacher should not offer students ready-made solutions. It is important to instil in the student the ability to ask questions, suggest hypotheses, to look for a solution, conduct analysis of what happened (Skurikhina, 2017a, 2017b).

However, at the moment many teachers of robotics are guided by work on ready schemes and algorithms, often there is "coaching" of pupils on result that doesn't give necessary effect. It is connected with the fact that there are no qualitative methodical handbooks on robotics, there are problems with staffing of educational robotics. Besides, robotics often remains for children entertainment, a game and doesn't promote formation of engineering thinking and readiness for professional activity in the technical sphere.

The analysis of russian and foreign researches indicates insufficient development of a technique of research competence and engineering thinking development by means of robotics. All of this creates a problem, which is expressed in the necessity of realization of didactic possibilities of robotics on the research competence and engineering thinking formation.

Purposes and Research Problems

The objective of this research consists in development of a technique of research competence formation by means of robotics.

On the basis of a goal the following tasks have been allocated: the analysis of methodical and theoretical bases of research competence and engineering thinking formation by means of robotics, the analysis of best practice of using research tasks and research projects on robotics classes and also methods of school students training in carrying out an educational research; development of skills of independent research activity and abilities to use modern technologies at the solution of practical tasks; the offer of concrete methods, receptions and research tasks which promote formation of research competence and engineering thinking.

LITERATURE REVIEW

Questions of the organization of educational research activity are considered by many authors. At the same time, many authors note a role of educational researches in formation of engineering thinking, orientation to the choice of an engineering profession (Bukina, 2014; Dontsova, 2014; Sazonova & Chechetkina; 2007; Stepkina, 2013; Zinovkina, 1996). Engineering professions are oriented on specific, practical result, require the ability of the problem identifying, finding solutions, formulating optimality criteria and solution efficiency of the proposed solutions, the evaluation of the results obtained. All this forms research competence.

According to these authors the students solve a few tasks which are related to real-life situations and require the implementation of quite complex types of learning activities, including ... and educational research (Goloborodko, 2013). These educational technologies require that the students will solve research, creative tasks, pass the basic stages of research, get a clear view of the project activities stages and methods.

A big role in this process is given to the information technology. So, the issues of educational research activity in the conditions of informatization are examined in the works by Staroverova (2007), Skurikhina (2017a, 2017b). However, it should be noted that information technology is only a resource of solving different problems, which effectiveness should be evaluated on an equal basis with other resources.

The robotics study with the purpose of engineering thinking formation and orientation to choose the engineering profession is a relatively new trend in Russian education. This is due to the whole complex of problems: financial, logistical, personnel, methodical.

And there are few researches devoted to questions of educational robotics, in the majority couples authors pay attention to questions of studying the methods of modeling, designing, assembly of the simplest robots with different sets. Works of such authors as Yurevich (2005), Zlakazov (2013), Novogorodova (2013), Sitnikov (2014), Skorokhodova (2014), Filippov (2013) are devoted to it.

In the majority of publications single questions of robotics introduction in educational process are considered: aspects of key competences formation of: information, communicative, coordination, problem (Goloborodko, 2013), development of universal educational actions (Startseva, 2016; Ustinova, 2015), orientation to the choice of engineering professions and engineering thinking (Baltser, 2015; Belenov, 2015), developments of lessons for the study of the specific robotic sets (Filippov, 2013; Koposov, 2015).

The most complete picture of a technique of robotics studying is presented in works of Koposov (2015) who considers questions of studying of robotics both at lessons, and in extracurricular activities. However, he pays attention to the use of robotics in other subjects (computer science, physics, technology), preparation for competitions, management of project and research activities. Studying robotics at the lessons of technology is presented in the works of S. A. Beshenkov.

Works of such authors as Natalevich (2014), Skurikhina (2017a, 2017b) are devoted to problems of research competence formation. Now it is possible to note some aspects of introduction of robotics in educational process. Robotics as a subject doesn't provide necessary conditions to prepare of engineering personnel for Russian industry as well as robotics industry. At the same time the most widespread practice is studying robotics within additional education. Models of studying robotics in the conditions of the general education aren't developed. Besides, at the present stage studying robotics happens on reproductive, sometimes heuristic levels and rather seldom (in isolated cases) moves to a creative level. During preparation for competitions still meets "coaching" of pupils, work on result (a victory in competitions, contests), but not on development of the identity of the child.

In works, which consider questions of research competences formation by means of robotics, the developed concepts and techniques are directed to formation of separate project and research abilities while the complex of abilities for performance of rather independent research is demanded by pupils. There is also the issue of gradual inclusion of students in research activities and problems of assessment of research competence.

The analysis of works of foreign authors allows to draw a conclusion that questions of development of research competence are in detail investigated in foreign literature. They are considered in works of such authors as Davidson and Palermo (2017), Hyusen and Tuyman (1991), Mulder (2012).

These scientists note that it is important to organize process of knowledge on the basis of researches and experiments when studying disciplines of a scientific and natural cycle. Much attention is paid to questions of motivation of students on carrying out a research, development of such necessary trait of character as "curiosity" (Scanlon, 2010). To ensure that the research process was naturally, children must not be afraid of wrong answers, and thus needs to be shaped a certain level of trust between student and teacher, and adopted the thesis that the process in this case more important than the result. In the process of educational research, it is important to ensure a certain autonomy of students, but the teacher is not removed from the process, he skillfully leads them, teaches problem solving strategies and organization of its activities, advises, directs and corrects students (Velde, 1997).

Today much attention is paid to questions of gradualness of research competence formation. So, the issues of research projects under the guidance of teachers, training in research techniques, and pedagogical aspects of the educational research, ICT in the organization of research work are discussed (Hamada & Hassan, 2017; McVey, 2013). Such development of organization of educational research and apply research in science discipline allowed the use of existing techniques in the study of robotics. However, the analysis of works of foreign authors identified the same problems as in the works of their Russian colleagues. For example, the works of Korcher (2014), Papert (1980), Surmann, Nuchter and Herzberg (2003) shows that they are also devoted to the use of specific robotic sets in educational activities. In the works of foreign authors there is also a tendency of the study not robotics, but the basics of working with Lego, Fisher Technik, and other sets. However, attention in publications is also paid to the use of robotics sets for studying individual phenomena, for example, when learning the concept of leverage. The experiments and carry out project tasks using a variety of robotic sets are discussed.

However, aspects of a uniform technique of research competence formation with means of robotics are presented consecrated in works of foreign authors insufficiently. The description of separate experiments and researches for studying of certain questions within a concrete subject is generally carried out.

All this shows relevance of the direction of research competence and engineering thinking formation by means of educational robotics.

MATERIALS AND METHODS

Theoretical and Empirical Methods

To carry out a research such theoretical methods were used: psychology and pedagogical, methodical and technical literature, the analysis of literature on research competence formation by means of robotics; robotic sets, software of programming the robotic devices in the context of requirements of the state, society, the identity of the trainee; forecasting, systematization and generalization of the facts and concepts, modeling;

Such empirical methods were used: the included observation, the stating and formation pedagogical experiment, questioning, testing, the analysis of results of skilled and experimental work.

Base of a Research

Approbation, generalization and introduction of results of a research are carried out:

- through training he robotics in the summer camp “Eureka”; classes are given since 2015 on the basis of materials prepared by the author;
- during the guide of regional innovative schools, which worked on the topics “Integration of robotics in the basic educational program”, “Educational robotics in extracurricular activities of College students”, “Network interaction of organizations and supplementary education for implementation of educational robotics»;
- by means of teaching at advanced training courses “Educational and competitive robotics”; the course is given since 2015 in the Institute of educational development of the Kirov region;
- by teaching at advanced training courses “Educational and competitive robotics” for teachers of robotics of the Center of additional education of “The Vyatka state agricultural academy”; the course is given in 2017 in “The Vyatka state agricultural academy”;
- by work within creative laboratory “Educational and Competitive Robotics”; the laboratory is carried out since 2015 in the Institute of educational development of the Kirov region;

in the form of reports and performances at scientific conferences and seminars of various levels, including international, publications in collections of scientific articles and scientific and methodical periodicals.

Investigation Phases

The research is carried out in three stages.

The first stage was conducted concerning the experiment: we study the state of problems of research competence formation by means of robotics with the requirements of the modern standard, society and the personality of the learner. This was the analysis of psychological and pedagogical, methodological and technical literature, robotic kits, software for programming robotic devices.

Besides, the analysis of the best practices of research competence formation by means of robotics, training of school students for carrying out research projects in the sphere of high technologies was carried out.

Within the second stage the analysis of research competence formation of school students on materials of the researches conducted in the summer camp "Eureka" and regional innovative schools was carried out (Lyceum of information technologies No. 28, municipal educational institution "Kirov station of young technicians", "Suburban college of pedagogics and the social relations"), certain problems have been revealed, the relevance of the conducted research is formulated. The presentation of the received results is carried out during work at advanced training courses, participations in creative laboratories, in the form of publications, performances at seminars, webinars and conferences.

In parallel with the second the third stage was implemented. During this stage there was an approbation of the offered technique in the summer camp "Eureka", on regional innovative schools, regional seminars and master classes. Also at this stage the pedagogical experiment which data confirm efficiency of the offered technique for Forming of research competence was made.

RESULTS

Methodical Aspects of Forming of Research Competence Means of Robotics

Let's formulate main principles of research competence formation by means of robotics.

The principle of practical orientation of tasks. One of essential characteristics of competence is the ability to solve real practical problems, based on the available knowledge and applying the created skills (Van den Berg, 2017; Vorobyeva, 2013). For this reason, one of the most important methodical principles of research competence formation is practical orientation of the offered tasks.

The most important feature of robotics classes is that practical activities is the base of educational robotics. That's why it is necessary to use the practice-oriented tasks connected with reality. For example, the task to create the robot which will execute search of an exit from a labyrinth can be set (the concrete robot and a concrete labyrinth is known).

Very important resource of practical tasks is the possibility of verification of the solution proposed by the child in practice. Modern educational robotic sets allow to report program to memory of the robot and to carry out test, that allows to see results of work visually.

Besides, when studying robotics (unlike studying programming, modeling), the pupil is not in virtual space, and he can feel physical sense of studied processes. Children can learn by own experience that operation of the robotic device is influenced by various physical phenomena: friction force, existence of obstacles, level of illumination, sound insulation and another. It allows to prepare school students for implementation of projects in actual practice.

The practical nature of activity is the main advantage of robotics. As a result of the robotic project implementation the concrete product which results of work can be measured, analysed, kept track is made. It provides additional motivation on the solution of tasks and carrying out a research.

The principle of multi-variant solutions. The very important aspect is that the pupil shouldn't get used to ready decisions (both design, and program). Traditional methods of training often limit natural children's ability to study, because they assume achievement of known decision, moving to him in the certain standard ways. Robotics gives the chance of search new, often uncommon, decisions. And if it is necessary to offer pupils research tasks from the very beginning of studying the robotics.

So, already at a designing stage after assembly of the robot according to the ready scheme during which the main details, ways of fastening, a concept of stability, the aspects influencing the speed and other characteristics of the robot are studied it is necessary to pass to research tasks: how to create the robot which will sustain freight of a certain weight; how to create the robot which will have high-speed characteristics; whether heavier robot guarantees a victory in the competition "Sumo"?

It isn't necessary to propose ready solutions of programs for the robots. It is important to form ability to ask questions, to make hypotheses, to look for the decision, to carry out the analysis of results. So, after studying of the movement of the robot forward and backward it is possible to solve such research task: "how to turn the robot on 90°". This task assumes the analysis of ways to turn the two-wheeled mechanisms, adaptation of information about programming of movements of the robot obtained earlier and the offer of own methods to turn. After possibilities of the movement, turns are studied, it is possible to offer several research tasks. For example, it is possible to give such task: "Bring the Robot out of a Labyrinth". This task assumes integration of all available knowledge.

At the same time children can request different versions of the solution. In order that pupils were ready to propose own solutions, it is important to remember the following aspects:

- promotion of inquisitiveness. The teacher has to be ready that at different stages of occupation pupils will have a mass of questions. It is important to give the chance to formulate these questions, to discuss possible answers, to experiment, check the hypotheses. At the same time a particular interest and motivation of pupils is caused by the involvement of the teacher into process of search of the decision. The teacher can join to the discussion, an experiment and the analysis of results. It allows to be convinced that ready decisions don't exist and the teacher looks for answers with pupils. Often in robotics there is a situation that children propose absolutely unexpected, interesting solutions.
- adequate relation to wrong ways of solving the problem. Children are afraid to be mistaken, receiving a question, they seek to find only the correct answer. In robotics classes it is important to create lack of fear of incorrect decisions and also ability to analyze the causes of problems (the wrong performance of a task, existence of technical failure, etc.) and also to draw conclusions from the arising wrong situations. It brings closer process of the solution of a task to the solution of tasks in the professional sphere.
- creation of the atmosphere of trust and respect for teacher, each other, process and results of cognitive activity.
- decrease the role of assessment. It is important for pupils to form an understanding that evaluation as such is not important, the main things are the knowledge, skills, skill sets and experience they receive. It needs to attract self-evaluation, mutual evaluation, to apply a formative assessment, have the developed system of evaluation criteria.
- understanding that process is more important than result. Process of a research, knowledge has to be interesting to students. It is important to answer questions: how to solve a problem, which of methods is be the most effective, but not just to receive result in any way.

It is important to understand that different students can demonstrate different results of the same task. Besides, one pupil can try to solve a problem in the different ways. It allows to pass to a problem of assessment of optimality of the offered versions. In real life the optimality of the decision depends on many factors: problem definitions, existence of material conditions, requirements of the minimum cost. It is very important to teach school students to mark out criteria by which the result of work will be estimated and also to estimate work on these criteria, to carry out comparison and to draw conclusions. It will help development of reflection skills, will allow to estimate results of own work adequately.

Principle of the presentation of the results. For the technical specialist it is very important to be able to carry out the presentation of results of his work in different formats: from preparation of article to an oral performance with demonstration of operation of the robotic device. At the same time, it is important to form ability to work with technical documentation and to organize work with different types of the project documentation: specification, passport of the project, engineering book. Also so-called "soft skills" including ability to present the work are important for future expert. Abilities to act, present, "sell" results of the work are very important, but they are rather rare for technical specialists therefore you shouldn't feel sorry for forces on their formation. It is worth beginning with pronunciation of results of work, their discussion with members of collective. Gradually the habit of pronunciation of results of work will become a basis for a competent performance and the presentation of work.

Principle of systemacity. It is important to understand that process of a research is the uniform process including all aspects of activity of the pupil, his interaction with the teacher therefore it is important to provide all aspects of carrying out an educational research.

Principle of gradualness. Process of research competence formation has to be gradual, systematic. It is impossible at once to teach the child to conduct researches and to give him free rain. It is necessary to pass gradually from completely operated process with separate research tasks to an independent educational research. At the same time it is important to consider features of children, their readiness for independence in the solution of objectives as the excessive difficulty of solvable tasks can lead to loss of interest in training.

The principle of subjectivity assumes accounting of such personal characteristics of students as orientation of the personality, valuable installations, interests and priorities. It can be shown in the choice of subjects of research projects, methods of the presentation, the organization of interaction in student's collective.

The principle of training in collective. Questions of training in cooperation are especially relevant for future experts since one of competences of the future is the teamwork. Now engineering projects have reached such level that they aren't implemented alone but only by big groups of developers. Work in couples, groups allows to simulate a cooperation situation for the solution of professional tasks and also to create communicative skills.

Thus, we have offered the following methodical principles of research competence formation by means of robotics: the principle of practical orientation of tasks, principle of multi-variant solutions, the presentations of results, systemacity, gradualness, subjectivity and the principle of training in collective.

Basic Provisions of a Technique

The offered technique is based, first, on structure of the research competence offered by Vorobyeva (2013). The research competence assumes existence of a certain knowledge:

- fundamentals of sciences (terminology, main methods); K1
- main terms of a research (object, subject, purpose, tasks, relevance, hypothesis, methods); K2
- main directions of researches in modern science; K3
- stages of research activity; K4
- types of representation the research results; K5
- criteria for evaluation of a research; K6
- ethics of the young scientist. K7

At the same time, it is very important that all this knowledge is gained and reported during the solution of practical tasks, that is the pupil receives them when it is necessary. It solves a motivation problem on obtaining theoretical knowledge. At the same time, it isn't necessary to force children to learn definitions of the concepts "hypothesis", "object", they are entered at discussion of tasks, for example if teacher makes question: "Let's discuss what robot can win the Sumo competition» and children offer the answer "The heaviest robot will be a winner", then the teacher explains: such assumption will be a hypothesis of our research. At the frequent use the term is remembered and accepted as natural and necessary.

Also research competence demands such skills:

- to allocate a problem; S1
- to define an object and a subject of research; S2
- to formulate a research subject; S3
- to formulate the purposes and research problems; S4
- to formulate a hypothesis and to define the plan of confirmation or a denial; S5
- to make the plan of carrying out a research; S6
- to pick up information sources; S7
- to generate the ideas, versions of the solution of an objective; S8
- to assume the reasons of the phenomena and processes; S9
- to analyze, compare, do generalizations and conclusions; S10
- to correlate the received result to goals and tasks. S11

If the school student is faced by a specific practical objective (what robot can win the competition "Sumo"), then all these abilities will be formed naturally.

The last component of research competence – experience:

- works with various sources, information technologies; E1
- selection of methods for a concrete research; E2
- works with the simplest devices (robotic sets, measuring devices); O3
- organizations of polls, interview; E4
- fixations and processings of results of researches; E5
- registrations of results of a research and their presentation; E6
- justification of the practical importance of the conducted research. E7

Second, the methodology of research competence formation by means of robotics is based on the principles formulated by the authors: the principle of practical orientation of tasks, principle of multi-variant solutions, the presentations of results, systemacity, gradualness, subjectivity and the principle of training in collective.

Third, with the development of the methodology took into account the stages of the research described in claim 1.1. this article.

The technique is based on the fact that research competence formation begins with introduction of separate research tasks.

The research task in this case is a practical task which contains research elements. Most often for this task ways of the solution aren't known, the pupil conducts search of the decision and assessment of its efficiency.

Example 1. Children have assembled the cart which moves in a straight line during certain time. The teacher sets a task: it is necessary to change a design so that the cart maintained the maximum freight.

Let's analyze this research tasks from the point of view of research stages. This necessarily to give such notions as the purpose of the research, object, subject. Pupils can offer a research hypothesis, and it is possible to organize collective discussion on the basis of which everyone will make the independent decision. Scheduling is carried out by the teacher, offering to children time for decision of the task, the approximate sequence of actions. The stage of the search and analysis of information obtained "rolled", because this information is obtained students earlier, they need just to remember it. Then there is the development of design and experimentation, during which the student collects empirical material, and form for the collection of material can be offered by a teacher (usually a table or a chart). Data collection can be conducted by each student individually and collectively (e.g., to hold a general start the truck and record the maximum load which it could take). It is necessary to hold a joint discussion of the results of the study, speaking of insights, conducting reflection.

Depending on how well developed the students research competence will differ the level of autonomy of pupils and the degree of teacher participation.

Example 2. After school students learn to program the movement and turns of the robot, there is a problem of passing of a certain route. And during the solution of this task children face such problem: at turn there is a robot shift that complicates algorithm execution. And then they have a question: "how to execute turn that there was no shift?". The teacher suggests pupils to find the answer independently, at the same time it is possible to compare the decisions received by different pupils.

In this case pupils independently carry out formulation of a problem and problem definition. It becomes possible thanks to practical character of solvable tasks and collision with a problem situation. Pronunciation of the basic concepts is still carried out by the teacher. Pupils can offer a research hypothesis, and it is possible to organize collective discussion. As the work algorithm is already familiar to children, they carry out planning, but the teacher asks them to speak the sequence of the performed operations (premeditation of an algorithm, writing the program, loading the program in memory of the robot, work check) and focuses attention that it is the plan of the solution. The stage of search and the analysis of information still turns out "rolled" as it is necessary just "to remember". Development of a design, collecting empirical material is carried out independently. And again the speaking of the results of the study (in pairs, groups), speaking of insights, conducting reflection is necessary.

Another interesting research task is to write a program the robot's motion at the segment of a circle knowing only the basics of programming movement and turns.

It is necessary to complicate the job gradually: to go from individual elements of the research to the full research process, to set open tasks.

Example of an educational research which can be conducted within one occupation under the leadership of the teacher is preparation for the competition "Sumo" (and the level of independence of pupils can be varied depending on their individual characteristics). The main stages of realization of a research are presented in [Table 1](#).

Table 1. Stages of carrying out research "Creation of the Robot Sumo wrestler"

Stage	Maintenance of the Stage	Note
1. Preparatory stage		
allocation of a problem	Announcement of a competition. Organization of discussion of competition conditions.	Children are quite capable to formulate a research problem independently: to develop and programming the robot which can win competitions
statement of the purposes and research problems	Purpose: to construct the robot which will win a certain number of competitions, i.e. will be the steadiest	Children carry out independently
formulation of a working hypothesis	Usually a hypothesis sounds so: The most massive (heavy) robot is a winner.	Children carry out independently
scheduling.	Pronunciation of stages of work: considering and discussion in couples design of the robot, designing, discussion of algorithm, programming, testing of the robot.	Since stages are standard, children know their sequence. But they don't realize that it is the plan of a research. The teacher has to pay attention to it and pronounce these stages with children.
2. Carrying out research		
information search;	Children can watch the small video with record of the competitions "Sumo" on the basis of which they will be able to analyse different designs.	Children can use also any other sources of information.
the analysis and assessment of the obtained information;	Decision-making on the basis of the available information: what design will be adequate.	
collecting own material;	This stage assumes assembly of the robot, programming and carrying out tests. During tests it can become clear that not only the size and weight are important.	The teacher acts as the consultant
material processing;	At this stage it is possible to execute the set of data in the table (it is carried out in parallel with previous)	The teacher can act as the judge
generalization, analysis;	The analysis of results of the table	Under the leadership of the teacher
conclusions.	Formulation of conclusions, confirmation or a denial of a hypothesis	Under the leadership of the teacher
3. Estimated stage		
result assessment;	This stage involves correlating target: have we achieved the goal. If not, why not.	Under the leadership of the teacher
representation of results of a research;	It can be just discussion of that: what principles of creation of the robot have been chosen whether they were repaid.	Under the leadership of the teacher
reflection and encouragement of pupils.	Assessment of process of work over research	Under the leadership of the teacher

When determining what stages are realized by the teacher and what by pupils under the leadership of the teacher and what by pupils independently, it is important to be guided by the level of independence of pupils, level of their research competences formation. At the same time, it is important to remember that the teacher has to be mobile and adapt to the current situation.

Of course, such research isn't yet an example of completely independent research as his stages and results are in advance defined and are supervised by the teacher.

The solution of the problem of use of the robot in life can become an example of the research project. For implementation of such project children have to formulate a research objective, define functions of the robot, execute his designing, programming, testing of opportunities, the analysis of how received result conforms to the stated requirements. Besides, by preparation of the project it is also necessary to carry out search and the analysis of information, the analysis of the existing developments, justification of need of a new product development.

Thus, gradual formation of research competence assumes the movement from the research tasks to researches and then – to research projects.

Table 2. Structure of the table of a reflection

Stage	Assessment		
	executed independently	executed with the help	not executed
1. Preparatory stage			
allocation of a problem			
statement of the purposes and research problems			
formulation of a working hypothesis			
scheduling.			
2. Carrying out research			
information search;			
the analysis and assessment of the obtained information;			
collecting own material;			
material processing;			
generalization, analysis;			
conclusions.			
3. Estimated stage			
result assessment;			
representation of results of a research;			
reflection and encouragement of pupils.			

Problem of Assessment of Forming of Research Competence

There are different variants of assessment of research competence formation. Vorobyeva (2013) in her work suggests to carry out assessment of all components of research competences: knowledge (K1-K7), skills (S1 – S11), experience of activity (E1-E7). For each competence the three-ball scale is set: 1 point – the low level, 2 points – the average level, 3 points – high level.

Levels of research competences formation decide as a result of complex observation, questioning, testing of pupils, accounting of performances of children on messages, educational researches, research works on school, municipal, regional, All-Russian scientific events for school students. Criteria for assessment of level of research competence formation are defined by expert group especially. Monitoring is carried out by several teachers working with children, the psychologist, the class teacher. Total calculations of results are carried out collectively. It should be noted that it is rather labor-consuming, demands attraction of a large number of experts.

Other option of assessment of research competence formation is a reference of the pupil to one of levels of research competence:

- instructive and performing;
- reflective and reformative;
- partial and search;
- research;
- creative.

It also demands additional preliminary work: development of the system of tasks and criteria of their estimation.

It is possible to offer maintaining tables of a reflection (Table 2).

At first the teacher can keep such tables, gradually connecting to it commanders of groups, and then also pupils will be able to carry out such assessment. Of course, such tables will be filled out not on each occupation, and during the work on quite large projects where the level of independence of pupils is rather high.

DISCUSSIONS

Means of educational robotics can successfully be applied to research competence formation and engineering thinking of students. The efficiency of application of robotic sets is confirmed by the fact that the solution of tasks in robotics has practical character and is brought closer to technology of the solution of professional tasks of future engineers. Process of an educational research is brought closer to process of carrying out scientific research in modern economic conditions.

Practical orientation of tasks increases motivation and also allows to check the solutions of an objective proposed theoretical options in the empirical way. The skillful organization of an educational research contributes to the development of all types of universal educational actions: informative (statement of a problem, information

search, the analysis, generalization, etc.), regulatory (scheduling, control of results, correction), communicative (the organization of communication in group, the presentation of results of work), personal (self-determination).

The gradualness of research competence formation will provide natural process of formation the independence at the solution of tasks, will provide ability to put a problem, to offer versions of the decision, to select criteria for assessment of the offered options. All this will provide further a possibility of the solution of both professional, and personal tasks, and, as a result, formation of the successful personality.

As supporters of research training note, educational process ideally must model process of scientific research, search of new knowledge. In the most generalized view research training assumes that the pupil puts a problem which needs to be resolved, makes a hypothesis, offers possible ways of solving the problem, checks it, on the basis of the obtained data draws conclusions and generalizations.

Essence of research activity is:

- saving research behavior of pupils as a means of development of informative interest and formation of motivation for learning activities in elementary school;
- the development of students' ability to take a research position, to independently set and achieve goals on the basis of application the elements of the research activities in the curriculum and system of additional education in primary school;
- development of research competence and pre-professional skills as the basis for profile training in high school.

Besides, research works on robotics allow to form engineering thinking, to carry out an early profiling, to contribute to the development of all-educational abilities, so, promote formation of future expert and full participant of modern society (Skurikhina, 2017a, 2017b)

The received results can be used:

- for improvement of methodical systems of teaching robotics in the educational organizations;
 - for development of methodical system of training of future teachers for teaching robotics;
- for development of methodical system of training of teachers within the system of professional development.

CONCLUSION

The approbation of application of robotics for research competence formation and engineering thinking has allowed to offer methodical approach to the organization of training in robotics. The value of work is that in it the methodical principles of research competence formation by means of robotics are formulated and also the technique of gradual research competence formation from research tasks to research projects is considered. The offered technology of application of research competence formation by means of robotics:

- 1) promotes systematization and generalization of results of the previous researches in the direction of research competence formation by means of robotics;
- 2) considers features of robotics as practice-oriented, knowledge-intensive and hi-tech kind of activity.

Also the methods of research competence formation and planning of researches are offered, recommendations concerning logic of research competence formation are formulated in article. Possibilities of research tasks on research competence formation are described on concrete examples.

Thus, the offered methodical approach reflects specifics of research competence formation by means of robotics. Materials of article can be useful on the practical level to teachers of school during planning lessons of robotics. Besides, the presented developments can be applied in training of students who will teach robotics (future teachers of technology, information scientists, additional education) and also at advanced training courses of the experts who are engaged in training of children.

The efficiency of the offered technique is confirmed by the high level of motivation of students on studying the robotics in the summer camp "Eureka", in the regional innovative schools, participation and victory in robotics competitions of city, regional and federal levels.

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