REFERENCES

1. Kotova N.V., Osipov P.N. Stimulirovanie professional'nogo samoopredeleniya shkol'nikov k poluchenіyu inzhenernogo obrazovaniya [Stimulating engineering career choice of schoolchildren]. Obrazovanie i pedagogicheskaya nauka v modernizatsii rossiiskogo obshchestva [Education and pedagogical science in modernizationof Russian society]. Moscow: Publ. ITIP RAO, 2012, pp. 330-336. (In Russ.)
2. Putin V.V. Stenogramma zasedaniya Soveta po nauke i obrazovaniyu 23 iyunya 2014 goda [Transcript of the meeting of the Board on science and education, 23 June, 2014]. http://www.kremlin.ru/events/ president/news/45962 (Accessed 11.05.16).
3. Dehaas J. Students like diploma-degree option at Guelph-Humber. The Maclean's Guide to Universities. http://www.macleans.ca/education/university (Accessed 14.08.2014). (In Engl.)
4. Demoulin E., Murphy J. Representations temporelles et decision dans la relation de conseil en orientation scolaire. Lorientation scolaire et professionnelle. 2005, vol. 34, no 4, pp. 479-498. (In Fr.)
5. Hughes K.L., Bailey Th.R., Karp M.M. School-to-work: making a difference in education. Phi Delta Kappan. 2002, no 4, pp. 272-279. (in Engl.)
6. Razumova M.V. Proforientatsiya v Rossii: stanovlenie, problemy, perspektivy [Career guidance in Russia: development, challenges, prospects]. Professional'noe obrazovanie i obshchestvo[Professional education and society]. 2014, no.3 (11), pp. 49-57. (In Russ., abstr. in Engl.)
7. Tolstoguzov S.N. Opyt proforientatsionnoi raboty za rubezhom [International experience in career guidance]. Obrazovanie i nauka [Education and science]. 2015, no., 1(120), pp. 151-165.
8. Faizrakhmanova A.L. Formirovanie proforientatsionno znachimoi kompetentnosti u uchashchikhsya srednikh klassov obshcheobrazovatel'noi shkoly [Development of professional valuable competency at secondary schools].Avtoreferat dis. kand. ped. Nauk [Dissertation theses]: 13.00.01. Ioshkar-Ola: Publ. Mariiskii gosudarstvennyi universitet, 2014, 23 p.
9. Malin S.V., Kozhevnikov A.E. K voprosu o spetsifike proforientatsii v postindustrial'nom obshchestve [Career guidance in postindustrial society]. Teoriya i praktika obshchestvennogo razvitiya [Theory and practice of public development]. 2010, no.3, pp. 144-148. (In Rus., abstr. in Engl.)
10. Bardina I.V., Zemlyanukhina S.G. Rynok intellektual'nogo truda v innovatsionnoi ekonomike Rossii [Intellectual labour market in innovative economy of Russia]. Vestnik Saratovskogo gosudarstvennogo tekhnicheskogo universiteta [Vestnik of Saratov State Technical University]. 2010, vol.4, no.1, pp. 207-217. (In Russ., abstr. in Engl.)
11. Demeshko L.V. Proforientatsionnaya rabota na urokakh tekhnologii kak sredstvo sotsializatsii uchashchikhsya [Career guidance in "handicraft" classes as a means of social adaptation of children]. Aktual'nye voprosy razvitiya obrazovatel'noi oblasti «Tekhnologiya» [Actual issues of subject area "Handicraft" development]. 2013, no.1, pp. 67-71. (In Russ., abstr. in Engl.)

UDC 371.842

Pre-University Engineering Training for Children

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The paper considers engineering training provided for children in terms of its objectives, content, methods, and ways of implementation.

Key words: engineering education, additional education of children, organization of training.

Recently, the interest in children's engineering additional education has significantly increased. To develop children's engineering abilities and bring up engineers and scientists of the new generation, innovative models of children's additional education are widely introduced. Among them: joining of Russia WorldSkills International and organizing centers for skill and competency development SkillsCenter, participating in international competitions World Robot Olympiad and RoboTraffic, arranging children's technology parks "Quantorium", etc. One can conclude that additional education is taking a new turn in developing children's engineering and technical creativity.

The goal of our research is to determine the prerequisites of new stage in children's engineering-technological creative development, as well as to describe the trends in children's general engineering training and training of future engineers as a part of additional education.

The system of extracurricular training and education of various artistic profiles including engineering ones was intensively developed during the Soviet era. A wide network of young technicians' clubs, technical art centers, local clubs, technical unions were organized. In N.N. Yartsev's opinion (dissertation of 2006), the system of children's engineering art has gone through the following stages: 1 stage: (up to 1918) – syncretism; 2 stage: (1918-1939) – development; 3 stage: (1940-1960) – maturity; 4 stage: (1961-1986) – boom; 5 stage (1987-1992) – crisis; 6 stage: (1993 – present) – transformation [1].

From the standpoint of content, the transformation stage of children's additional engineering education is conditioned by intensive development of new technologies. Thus, in January 2016, Klaus Schwab, the Presidents of the World Economic Forum in Davos, made a report about the fourth industrial revolution that had emerged and developed since the middle of the last century. Its peculiarity is a fusion of technologies dissolving the initial boundaries between material, digital, and biological worlds. The first industrial revolution was based on using water and steam power to save labour and develop industry, while the second one used electricity to increase the scale and development of mass production, the third one rested on electronics and information technologies for production automation, while the fourth industrial revolution is aimed at development of cyber-physical systems based on big data technology, Internet of things, virtual and augmented realities, 3D-print, printed electronics. In scholars' and practitioners' opinion, the latter will lead to enormous changes of economy and industry in the near term. The new economy needs staff with not only new engineering but also relevant communicative skills – users and creators. It is due to this fact that engineering education development in Russia is now a strategic objective for Russian economic safety and development of human capital.

Engineering education originates in the childhood when acquiring natural-science and engineering knowledge is of particular significance from the standpoint of children's age and psychological peculiarities. At the

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school age, children learn properties of items, study and construct mechanisms with great interest. At primary school children's visual and logic thinking is intensively developed. At the middle school, more attention is paid to learning natural science and physics-mathematical subjects.

Goals and objectives of engineering education are defined in the National Doctrine of Advanced Engineering Education. On the one hand, it is mass training of children and youth in using innovative and modified devices and technologies in life and job, on the other hand, extraordinary professional competencies of those capable of generating engineering ideas, taking engineering decisions, developing, producing, and maintaining the competitive engineering constructions. Whereas the solution of the first problem aims at increasing the level of engineering culture of the society, the second one is focused on formation of science and technology elite for new industrialization of the country and reinforcing the role of Russian engineers on the world market [3].

Within the period of per-university education children are involved in engineering design through additional education that includes clubs, centers, unions, research labs, technology parks, design bureaus, research teams, events held in technology and engineering sphere functioning on the basis of general educational, secondary professional education institutions and universities, as well as additional educational institutions.

The advantage of children's additional education is implementation of flexible educational programmes that allow for maximal support to and development of children's interest in new knowledge and activities in the sphere of technology and engineering. Children get an opportunity to acquire positive social and personal experience. In the condition of children's education one can identify the two main tasks of engineering education:

1) To increase the level of children's general engineering culture.

2) To reveal and support children talented in the engineering sphere.

Based on these tasks, the model of children's additional engineering education may consist of two concepts: general engineering training and future engineers' training.

From the standpoint of content, children's general engineering training includes such profiles as:

- transport: surface and underground (railway and road), water and underwater, air (aerostatic, aerodynamic, airplanes, helicopters), space;
- building and road building machinery: digging machine with steam engine, excavators, caterpillar machines, carrying and lifting equipment, mixing facilities cranes, elevators, piling hammers;
- military machinery: infantry and fire weapon, battleships, tanks and armored cars, naval engineering, military aircrafts, etc;
- equipment used in everyday life: stove, refrigerator, washing machine, iron, coffee maker, steam cooker etc;
- communication technology: telegraph, telephone, radio station and radio receiver, phonograph, gramophone, telecommunication etc.;
- technical development at different historical periods.

The content of these topics is briefly reviewed, the main operation principles are considered, the models are designed and tested. Both traditional construction sets and robotic, electronic, radio electronic, printing 3D technologies can be used for modeling.

The plan of lessons should give more possibilities for children to creatively develop their activity of learning new laws, concepts, categories, and phenomena. This can be provided by prevalence of problem-research and artistic methods over reproductive ones.

The reproductive methods in engineering education suggest:

- delivery of knowledge;
- assembly of engineering models from ready details using samples, pictures, descriptions, or instructions;
- making experiments and model observation.

The problem-research methods focus a teacher on:

- creation of problem training situation;
- pupils' stating the experimental problems;
- team discussion of possible approaches to an engineering problem solution;
- introduction of changes in a scheme or model construction.

The artistic methods are aimed at arrangements of:

- pupils' individual artistic ideas on developing projects of engineering objects;
- intensive search for the ways of solving inventive and artistic problems.

The general engineering lessons are delivered both in the classrooms and outside the classrooms. At home or in the street, pupils watch the operation of domestic, building, and road machinery, then construct and design automated and robotic models. Children participate in the events aimed at promotion and development of children's engineering art: days of science, festivals, exhibitions, competitions, workshops, etc. The main purpose of these events is not only competitive, but also motivating.

Children learning this field cannot choose engineering job in future, but they will become more sensitive and prepared for using engineering and technological innovations in everyday life and at work place. General engineering classes become a place where children show their inclination to engineering art, develop their engineering thinking, get interested in future engineering job.

The second part of engineering education model in the condition of additional education can be referred to as "Future engineers' training". In this case engineering education involves specialized work with children showing engineering creativity, as it is through the abilities' development that a person reaches the high level in professional and individual growth.

The content of future engineers' training is defined by the following trends:

- impact of scientific discoveries and practical artistic thought (designers, technicians, inventors) on engineering development;
- production (industrial) machinery: mineral extraction and processing (mining, organic synthesis), processing (metallurgy), material treatment (mechanical, chemical), other industries (machine-building, communication, electronics);
- power machinery: thermal power (thermal plants), electrical power plants (energy transition and production);
- reduction of adverse effect of engineering progress: water pollution, soil and air pollution, its impact on flora and fauna, crucial disturbances in the planet ecosystem.

When studying these trends, it is necessary to connect research with physics sections (mechanics, bases of kinematics, bases of dynamics; bases of electrodynamics and electrostatics, etc.), informatics (programming, simulation, and social information).

At the lessons, the most significant thing is artistic activity that makes children think. It is always connected with creation of something new, discovery of new thing, and new abilities in oneself. Besides, artistic activity strengthens positive self-assessment, increases ambitions, and results in self-confident and satisfaction with the achieved results. The role of adults is also very important. They become helpers, organizers, and tutors providing assistance in cognitive activity that enables to turn a pupil from an object to a subject, transit to self- and mutual education and self-development. Parents, teachers and tutors of additional education can and should help a child to reveal his/her creative potential, show his/her best qualities, and maximally realize potentialities.

An important stimulus for engineering art at a higher level is children's training and participation in competitions, Olympiads, contests of different levels: from local educational to All-Russian and international events. There are competitive and artistic constituents in such events. The artistic constituent implies initial setting the problem and evaluation criteria. Based on the problem the participators develop an idea

independently, define the goals and objectives of their project, and suggest the ways of problem solution. Within the competitive constituent the problem is defined by the organizers, whereas participators should find the most efficient way of its solution.

The examples of locally-distributed engineering events are as follows:

- Russian research social programme for youth and pupils "Step into Future" (www.step-into-the-future.ru);
- All-Russian Robotic Festival "Robofest" (www.russianrobofest.ru);
- All-Russian Robotic Olympiade http://robolymp.ru;
- All-Russian competitions IKaR and IKaRenok (Engineering staff of Russia) www.ikar.fgos.rf, etc.

One more trend of future engineers' training is cooperation with industrial enterprises, which can be arrange via excursions to enterprises, supervision of children at their project work, delivery of classes and workshops by enterprise experts. Children can observe both operation of definite machines and mechanisms and the entire production at the excursion. An insight in the real production process guides the pupils towards engineering profession.

An important area of work with future engineers is professional guidance of senior schoolchildren assisting to choose engineering profiles at educational institutions of secondary and higher education. This area implies professional guidance meeting with authorities, teachers, students, graduates of these institutions as well as workshops, competitions, and festivals (table 1).

Hence, future engineers' training over the pre-university period has content and methodical potentials in the condition of children's additional education. Nevertheless, resource base and teaching staff for classes of engineering art require to be supported by government, business, and society.

Table 1. Models of children's additional education

Children's additional engineering education		
Trends	General engineering training	Future engineers' training
Target audience	Users	Creators
Key objective	To increase children's level of general engineering culture	To revealing and support children gifted in engineering
Content	Engineering development in different historical periods. Transport, building, road building machinery, domestic equipment, telecommunication etc.	Effect of scientific discoveries on engineering development, reduction of adverse effect of engineering progress. Production (industrial) facilities, power engineering
Methods	Prevalence of problem-research and artistic methods over reproductive ones	Artistic method
Events	Motivation for learning – days of science, festivals, exhibitions, competitions, workshops etc.	Showing achievements – competitions, Olympiads, contests of different level

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REFERENCES

1. Yartsev N.N. Stanovlenie i razvitie sistemy detskogo tekhnicheskogo tvorchestva v usloviyakh dopolnitel'nogo obrazovaniya (na primere Samarskoi oblasti): diss. … cand. ped. Nauk [Emergence and development of children's engineering art system in the condition of additional education (by the example of Samara Oblast). Ph.D (Pedagogy) Thesis]. Ulyanovsk, 2006. – 297 p.
2. Evans D. Internet veshchei. Kak izmenitsya vsya nasha zhizn' na ocherednom vitke razvitiya Vsemirnoi seti [Elektronnyi resurs] [Internet things. How our life changes at the turn of Global network development]: Gruppa razrabotki internet-reshenii Cisco dlya biznesa (IBSG). [Cisco IBSG, cop. 2011.]. 14 p. URL: http://www.cisco.com/c/dam/global/ru_ru/assets/executives/pdf/internet_of_things_iot_ibsg_0411final.pdf. Accessed: 06.01.2017.
3. Pokholkov Yu. P. Natsional'naya doktrina operezhayushchego inzhenernogo obrazovaniya Rossii v usloviyakh novoi industrializatsii: podkhody k formirovaniyu, tsel', printsipy [National Doctrine of Advanced Engineering Education in Russia in the condition of new industrialization: approaches to formation, goals and principles]. Inzhenernoe obrazovanie [Engineering education]. 2012. № 10. – pp. 50–65.