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The Imperative of Engineering Staff's Intellectualization and Common Culture Enhancement

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The causes for stifling innovation in the country, reduction of the engineers' overall culture and quality of their training have been analyzed. The ways of the future engineer's personality development on the basis of domestic experience and modern TIPS tools are considered.

Key words: critical technologies, invention, intelligent property, solution of nonstandard problems, the integrity of a person, a common culture, «official» and «unofficial» education, experience of engineers' training in Russia, the TIPS tools, knowledge transfer.

There is a demand for "new industrialization" in Russia, which is closely related to drastic improvement in engineers' training. The tasks set for engineers of our country are rather serious. To understand this, it is enough to look at the list of critical technologies (Table 1).

Whereas in 1996 their list included 70 items grouped in 7 units (information technologies and electronics, production technologies, new materials and chemicals, living organisms' technologies, transport, fuel and energy, ecology and environmental management), by 2002 it has contained 52 items grouped in alphabetical order. In 2006 the list was reduced to 34 items, but the list of 2008was added with the item "Production technologies of metals and alloys with specific properties used in weapon and equipment production". Later, in 2011 the priorities became 8 items: safety and counter-terrorism; nanosystem industry; information and communication systems; life sciences; promising types of armament, military and special equipment; environmental management; transportation and space systems; energy efficiency and conservation, nuclear energy. The number of technologies reached its minimum – 27, the list included cognitive technologies for the first time.

Then, in 2012 the list grew again to 38 items. Technologies of information collection, retrieving, storage, possessing, accessing, and protection were classified separately. By 2013 the list was added with the following items: cryobiological technologies; development and production of immunobiological medicines; tissue, cell reproduction technologies in medicine and veterinary; genetic technologies.

The analysis of the changes leads to the following conclusions:

1) there are no electronics, production and aviation technologies; ecology, nanomaterials, new materials and chemical engineering are among the priorities;

2) number 1 is the item «Safety and counter-terrorism»;

3) high frequency of changes in the list and superficial priorities are noticeable. However, the major point is wide coverage of the list under the condition of limited financial resources. The priorities are updated in our country in the same way as changes are introduced in the form of reforms. In this way there are mergers of state-owned corporations, ministries, management bodies, but inadequate decisions do not improve the work of merged departments [1].

Public activities in the sphere of critical technologies reflect like a mirror the conditions of innovation policy. Its results are disappointing – the share of Russian innovative products in the international

Table 1. The years of adoption of critical technologies (CT) list

	Years						
	1996	2002	2006	2008	2011	2012	2013
The number of CT	70	52	34	35	27	38	42
№ of the document, a body adopted it, date	Order of the RF Government of 12 July, 1996 2728p-P8	Order of the RF President of 30 March, 2002 Pr-578	Order of the RF President of 21 May, 2006 Pr-842	Order of the RF Government of 25 August, 2008 1243-r	Order of the RF President of 7 July, 2011 № 899	Order of the RF Government of 14 June, 2012 № 1273-r	Order of the RF Government of 24 June, 2013 № 1059-r

market has not grown over the past decade and amounts 0.2-0.3% [2]. A clear indicator of "resource" development is absence of federal law on innovative activity in the country. Under those conditions it is natural that research-engineering staff is not in demand in Russia. At present, during the period of world economy crisis, collapse of oil prices, and complex economic-political situation around Russia, it is hoped for drawing authorities' attention towards inno-vations, in general, and engineering activity, in particular.

There is a proverb: "A good student is a good engineer, a bad student is a chief engineer". It presents the results of different trends in mind training: the first is focused on diligence, the second – decision taking in the condition of uncertainty. Forced "to merge" (when and where it is necessary) the "broken" pieces of knowledge into relative integrity, an inventive student, a truant, often appears to be more adaptive to the present every-day and working circumstances, where the necessary information is not always available.

It leads to awareness in importance of "harmonization of moderate professionalism and moderate dilettantism" in a person's professional development, as well as "harmonization of moderate socialization and moderate autonomy" in one's public life [3] as a fundamental program. One can support the idea by K. Marx "on professional snobbishness and professional cretinism" of specialists as well as B. Shaw's words about the fact that "narrow-focused specialist knows more and more about less and less things until he knows everything about nothing and nothing about everything".

When developing TIPS, G.S. Al'tshuller suggested his classification of problems corresponding to five levels of inventions (from small to pioneer ones) [4]. It was proved: to develop inventions of the first level it is enough to have special knowledge in the professional sphere. In fact, it means to find useful engineering solutions "missed" by other specialists. Those solutions are sometimes almost obvious. Every subsequent invention level (small, medium, large) is characterized by transcending the specialist's individual knowledge – into professional sphere in general, then – entry into interprofessional, and, in the long run, interdisciplinary spheres of knowledge. The level of non-obviousness for such solutions is growing. Their inventor has to search for the answer in the wide sphere

of knowledge accumulated by mankind; it requires full development of personal potential.

The history of our country attests that the importance of harmonic development was not just accepted, it was a program concept. The program of the Communist party implied the solution of triune problem: in the sphere of economy – development of appropriate physical facilities for communism (taking the first place in production per capita, achievement of the highest productivity in the world and the highest people's living standards); in the social-political sphere – transition to communist self-government (new public relations); in the ideological sphere – shaping a harmonious personality.

It is known that in struggle for the victory in social competition the quantity was often more important than quality. It was also true about inventions. There was a practice of researchers' informal communication with the officials of Goskomizobreteniya, the latter could give advice to correct the application design – so that an inventor's certificate could be obtained. Therefore, the invention statistics in the USSR should be treated sensitively (Table 2). But even comparison of Soviet period data with the existing system of industry property (IP) patent in Russia is discouraging (Table 3).

Russia lags behind the developed countries in inventions. From 2000 to 2010 the number of patent applications in Russia grows 1.5 times – from 28.7 to 41.4 thous. (compare: at present, China and Hon Kong produces more than 520, USA – more than 500, Japan – more than 340, and South Korea – about 180 thous. of applications per year). The analysis of growth (in terms of Rospatent annual reports) shows the outstripping growth in foreign inventors' applications. The patent applications of Russian inventor increased by 13% within this period, whereas those of foreign ones – 2.8 times, which is a visible indicator of growth in investors' and producers' interest in Russian market.

Patent dynamics is a good illustration of the country's economic life. The number of applications (Table 3) in 2013 as compared to 1988 had fallen 3.9 times. Taking into account that in the USSR most inventors' applications were made by domestic applicants, this difference amounted 6 times. In comparison with the present-day inventions (about one-third of them) the number of utility model application has grown, which is a clear indication of decrease in intellectual capacity of solutions developed in applications (to

Table 2. Dynamics of inventions in the USSR over 1975–1988 [5, p.25]

Key indicators	Years			
	1975	1980	1985	1988
Inventors' applications in Goskonizobreteniya, thous.	119.2	168.6	168.0	174.7
Registered inventions, thous.	44.1	94.6	74.6	84.0
Innovation proposal (IP) applications, thous.	4910.8	4758.8	4883.4	3996.9
The number of accepted innovation proposals (IP), thous.	4489.6	4529.3	4678.7	4018.1
The number of applied inventions and IP, thous.	3977.4	4048.0	4059.8	3419.4
inc. inventions	14.9	24.1	25.1	22.3
The authors of inventions and IP, thous.	4335.8	4650.3	4705.5	3982.8

Table 3. Dynamics of IP* applications in Russia

Type	Application to Rospatent per years					
	2008	2009	2010	2011	2012	2013
Inventions	41849	38564	42500	41414	44211	44914
inc. Russian applicants	27712	25598	28722	26495	28701	28765
Utility model	10995	11153	12262	13241	14069	14358
inc. Russian applicants	10483	10728	11757	12584	13479	13589
Design solution	4711	3740	3997	4197	4640	4994
inc. Russian applicants	2356	1972	1981	1913	1928	1902
TM** registration	57112	50107	56848	59717	61923	64928
inc. Russian applicants	30024	26448	32735	33252	34851	34621
PDO*** registration	35	30	63	58	66	39
inc. Russian applicants	31	27	56	58	61	28
Total:	114702	103594	115670	118627	124909	129233
Note: IP*– industrial property, **TM – trademark, ***PDO – protected designation of origin						

issue a patent for them it is not required to achieve the invention level). At the moment, in Russia there are only 1.6 thous. of patent attorneys as compared to 3,1 – in Germany, 10,1 – in Japan and more than 40 – in the US. In addition, the distribution of attorneys over Russia is uneven – 90% of them work in Central, North-Western, and Volga federal districts.

As for the role of cultural development for a man L.S. Vygotskiy argued that he equates a child's personality with his/her cultural development. It is a key aspect forming a personality's integrity. In philosophy the problem of "integral" person is one of the most important. According to M.K. Madardashvili, "a human being is dissipated in thousands of vessels, which are not linked with each other, – a human being is broken into different locations in space and time" [6].

It is known that every year substantial knowledge acquired by a man in the course of "official" education (at school, then at university) decreases, whereas the share of "unofficial" or random "occasional" knowledge acquired in family, in the course of supplementary and distant learning is constantly growing. It has formed a tendency [7]. At present, the oldest and powerful educational institution, a family (with its capacity to give integral education and "informal" knowledge), has become of particular significance. Engineering training at university, in-service training or other further education are also essential for development of education integrity [8, p. 136]. The leading domestic scientists proved the necessity to intellectualize education via: its fundamentalization; noospherization, humanization, and creatization; use of culture; informatization and integration of educational and research processes [9]. The journal "Engineering education" has already considered the potentials of TIPS developments to solve engineering education problems. We can give the additional arguments in favour of solving the key problems of engineers' training based on TIPS and the theory of creative personality development – TCPD (Table 4).

Solving the problem of education intellectualization it is important to remember the experience of engineers' training in our country. The experts underline: a strong support of Russian engineering universities by the country leaders led to economic infrastructure breakthrough in Russia of the 19th century – the first half of the 20th. In the 1880's thanks to an outstanding engineer, and, subsequently, the Minister of Finance I.A. Vyshnegradskiy, the secondary and primary engineering education was reformed. The electroen-gineering institute in Saint-Petersburg and Technological institute in Kharkov were established.

Under the reign of Nicolay II the second wave in numerous establishments of engineering universities was observed. By the beginning of the First World War the system of higher professional engineering and agricultural education in Russia left behind the German one, which was achieved due to target policy and significant investments in this sphere beginning from the mid 1890's [8]. By 1917 the country had possessed the engineering potential of German level, exceeding France. The USSR inherited from the Russian empire the strong system of engineering education. By 1925 in the USSR, only one new higher technical institution (Moscow Mining Academy) had been established. All other were transformed from the previously existed or arranged on the basis of evacuated ones from Poland and Baltics. A number of new institutions (Moscow Institute of Mechanical Engineering, Mendeleev Chemical Technology Institute, Leningrad Institute of Fine Mechanics and Optics, Moscow Textile Institute and Kazan Polytechnic Institute) were established on the basis of large specialized secondary schools. In the periods of Revolution, Civil War and repressions against educated social strata, the country lost up to 80% of qualified teaching staff. But in the 1930's the Soviet government realized the danger of dropping in the education level and started to restore the educational traditions (first of all – in the sphere of natural science and engineering education). S.P. Timoshenko, who left the country during the Civil War and visited the USSR as early as 1958, underlines [13, p.10]: "… Russian returned almost completely to the educational system, which had existed before the Communist Revolution. The traditions of old school appeared to be very strong and by means of the rest of old teaching staff it was possible to put in order engineering education destroyed during the Revolution".

The history evidences the establishment of reliable models of engineering education. An engineer with higher education was simultaneously a researcher, technical expert, and production manager (Table 5). Such a training system implied not only "fostering of intellect" and fundamental academic qualification, but also "fostering of will" and managerial abilities. The gap between practice of engineer and manager is viewed by the researchers (from the standpoint of education) as a degradation phenomenon, which was avoided only by some educational institutions (for example, Massachusetts Institute of Technology) [8]. Collapse of the USSR, development of "privatization" economy and then "kickbacks" in Russia undetermined the prestige of engineering labour, which had a negative effect on the engineering education. Domestic mass media added fuel to the fire.

Here is the analysis of 525 top news in 2009 (from February to June) and 365 top news in 2010 (from December 2009 to the middle of March, 2010) [18]. The results (%) are rather illustrative (Table 6).

The character of modern engineering activity requires a return to complex model including two-system model (engineer-manager, engineer-economist, engineer-researcher, engineer-teacher, etc.), but on a new base. However, it needs to be deciphered. In this case, it is important to pay attention to the fact that majority of problems, including engineering ones, are solved by analogy. T. Edison stated on this

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Table 4. TIPS in terms of education intellectualization

№	Trends	Description and potentials in TIPS application
1	Fundamentali-zation and universali-zation	Cosmism and mathematization of knowledge, development of scientific worldview. TIPS are often called "applied dialectics", it generalizes the system of laws in system organization, functions, development. There are transfer algorithms of production processes into invention problems. To solve them, the resources of phys-, chemico-, geometry-, bio-, socio-, and psycho effects are used
2	Noospheri-zation	Intellect has to be converted from "mind for itself" into noospheric-biospheric one. TIPS as a general theory of strong mind (GTSM) leads us to planetary thinking promoting "to think globally, but act locally"
3	Humanization	Requirement for intellectual integrity, morality, and spirituality. Development of synthetic intellect through Russian literature, Russian philosophy, Russian cosmism. TIPS tools work well in this sphere [10]
4	Creatization	Application of game technologies, development of creative envi-ronment, teaching creative life-long bases. In the course of TIPS acquisition a great number of game technologies are intensely used (for example, "yes-no" problems). There is a complex in "Development of creative imagination" [11]
5	Use of culture	Culture fosters intellect on the national-ethnical base, in language, national history. Without culture intellect is psychically instable. G.S. Al'tshuller developed the technique of writing phantasy (Register of scientific-fantastic ideas (RSFI), "Fantasy-2" scale. In TIPS pedagogy there is a number of approaches to TIPS and RSFI application in literature and language, history and music [12]
6	Informatization	It is often confused with education intellectualization. Using computer only at a user's level sometimes results in the opposite effect – deintellectualization. TIPS are supported by a number of products of "computer aided thinking" type. They were initiated by the project "Inventing machine". It is referred to artificial intellect
7	Integration of secondary educational and research processes	Learners' immersion into research process attunes to learning the world. Techniques of TIPS development through catalogue of tool statement and verification (techniques of technical conflict resolution, standards of invention problem solutions, laws of system development, etc.) are a vivid example of solving problem of education integration with exploratory research

Table 5. Characteristic of engineers' model development

№	Model	Comments
1	Engineer-manager of production (practice-oriented engineer)	In the Institute of Railway Engineers (IRWE) a student had to develop three projects (a bridge, sluice, steam engine), and in the course of internship he got experience in implementation of those projects. In the 19th century a lot of famous constructions (bridges and sluices) were built by the students together with their teachers. In summer students participated in construction work. In Saint-Petersburg Polytechnic College, one summer, a student-shipbuilder had internship in the port, the other – at machine building plant, the third – in sailing [8]
2	Engineer-economist	In the Institute of Professional Upgrading of Specialists the engineers' training as future leaders included large amount of economic knowledge. Engineering-economic and economic branches became independent later. In 1902 in Petersburg Polytechnic S.Yu. Vitte established the first Economic department. Whereas in commercial universities of Moscow and Kiev engineering departments were opened. The trend became international. In the USA engineering developed simultaneously with introduction of "management ideology". In the USSR the first graduation of engineers-economists (79 graduates) took place in 1927 at Industrial Department of Leningrad Institute of National Economy (earlier – Trade-Industrial Institute of M.V. Pobedinskiy)
3	Research engineer	The model of "phystech" was developed in 1916. (A.F. Yoffe and S.P. Timoshenko in Petersburg Polytechnic developed the project of physical-mechanical department, arranged a seminar (P.L. Kapitsa, N.N. Semenov were participants of the seminar). Thanks to P.L. Kapitsa, since 1919 Petersburg Polytechnic had trained engineer-researchers with unique qualification
4	Teacher engineer	The stages of professional-pedagogical education (PPE) [14]: "pre-systematic" (1865–1914); I stage (the 1920's – 1930's) – a network of institutions and merger attempt under Glavprofobr; their transfer to narkomats; phasing out institutes and colleges; II stage (from 1943 to the end of the 50's) – restoration of intermediate link in PPE – opening of industrial-pedagogical colleges (IPC); III stage (from the 60's to 1979) – organization of engineering-pedagogical departments (IPD) in polytechnic institutes; extension IPC network; IV stage (from 1979 to the beginning of the 90's) – establishment of specialized universities (Sverdlovsk Engineering-Pedagogical Institute, Kharkov Engineering-Pedagogical Institute), extension of IPD network in IPC; V stage (from 1991/92 to the present) – collapse of the all-Soviet system of PPE; in the RF – increase in the number of universities and colleges, qualifications of teachers for PPE and SPE (opening "non-engineering" specialties: "veterinarian-teacher", "economist-teacher"), since 1992/93 ac. year transfer to the multilevel system (Bachelor – Specialist – Master); standard introduction in 1996. HPE and SPE; in 2000 introduction of new classification of majors and specialties in HPE ("teacher of professional education" – for all types of specialty 030500 «Professional education» –19 of them)

issue: "If you want to invent perfect ideas, you should know: the best of them can be borrowed".

The world has accumulated a great amount of solutions, it is only necessary to find common, developed solutions and apply them to solve the other relevant problems. In patent sphere it is referred as "invention to use for a new purpose" (it is possible to use methods, devices, substances, microbial strain in this way). From the standpoint of inventions classification, such intellectual activity inevitably leads a solver beyond the bounds of professional knowledge (to the invention of 3-4 levels) requiring high common culture and wide worldview. The knowledge necessary for the use in other sphere can be found in quite unexpected place. As soon as the 1970's G.S. Al'tshuller described how students of public institute of engineering creativity (three students and a young engineer) chose a complicated problem for their diploma projects on aerial navigation. There had been attempts to solve it in several countries. Calculation was based on the fact that reliable solution had to lie outside the bounds of common ideas in navigation machine tool engineering. The required principle appeared to be found far from aviation area – in confectionary technology (!). The invention was awarded with experts' positive evaluation and the title of protection [4, p.18].

At present, similar intellectual activities form the basis for contemporary knowledge transfer [16]. Most solutions, developed by the foreign TIPS experts for the leading international companies, are performed in the same way [17]. Hence, it is hard to escape the conclusion that TIPS are a reliable base for transfer of innovations from one sphere of human activity to another in the theoretical-engineering aspect, which permits the transgression of inter-professional and interdisciplinary frameworks when solving a problem. Therefore, acquiring TIPS tools would solve the problem of engineering education intellectualization and enhancement of future engineers' common culture. The history evidences that great engineers of the past achieved a lot due to their high cultural standards [18]. We hope we would achieve the same.

Table 6. Analysis of mass media news in Russia in 2009–2010

№	News	Years	
		2009	2010
1	About achievements in nature studies	–	–
2	About engineering achievements	0.5	1.9
3	About well-doers	1.0	–
4	About Russia	7.8	9.9
5	International news	12.4	11.0
6	About wars, conflicts, terrorism	5.0	8.0
7	About crimes and criminals	10.3	11.0
8	About deaths, accidents, violence	17.2	24.2
9	About swine flue	4.2	–
10	Show-business	20.3	19.6
11	About nothing	9.5	5.2
12	Politicians' advertising	11.3	9.2

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Environmental Training and Education

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Article highlights issues of environmental training in secondary and higher education. Authors suggest universal formula of progressive education, which is targeted at unity and progressive development of Russia by means of environmental training. Current article is of conceptual kind and comprises different areas of environment.

Key words: environmental education, environmental training in secondary and higher education, universal formula of progressive education and training.

In the modern world, education becomes an important process in development of social and economic progress. During ecological crisis the educational system is the source capable of forming human qualities such as love, kindness, respect, mercy, compassion for others and Nature. Such moral qualities of a person are needed to understand value of life, responsibility for life preservation and great «reverence» for life.

Absence of such set of values prevents from application of modern clean technologies and environmental friendliness. What is needed is the review of all main types of relations: relations between man and nature, relationship between man and man. The process of training in the educational system acquires new tasks.

Education is inextricably, harmoniously connected with training that is to say that education and training are united. Therefore, universal formula of progressive education and training is as follows:

Progressive education and training form united harmoniously tightened process of formation of creative individuals with high level of knowledge, intelligence, patriotism and sports. Therefore it is necessary to significantly accelerate the process of patriotic education in Russia; suppress any distortion of history; imply criminal responsibility for promotion of fascism and nationalism.

One of the main areas of patriotic training is the environmental training: love for the motherland, for our Nature, goodwill, mutual assistance, formation of ecological intelligence and many other positive qualities. All of them eventually should be targeted towards the ultimate goal – to strengthen unity and progressive development of Russia.

In Russia in 2009 Danilyuk A.Ya., Kondakov A.M. and Tishkov V.A. issued "Concept of spiritual and moral development and training of individuality of a Russian citizen". This particular concept formulates core value milestones, moral norms, ethical standards, which can unite youth into a single historical, cultural and social community during tough times of the country development.

However, training of modern youth in the Russian educational system is almost untouched [2].

At schools, gymnasiums and lyceums training mostly stands for observing discipline. In educational institutions results of monitoring, ratings are considered as important parameter; families appreciate the results and achievements expressed in high grades. Main affords of teachers and parents are targeted towards successful results of Uniform state exam which is a

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