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Innovative Practice and Management Extracurricular Education System: Distance Technologies in Non-Formal Project-Based Learning

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Abstract

The paper describes the innovative system of the extracurricular project-based education program of high school students, combined with the national contest of research projects carried out in the learning process. This system is developed and managed in the format of a Society-State-Private partnership as an attempt to adapt education to post-industrial development.

The organization of extracurricular education in the form of a public-state partnership facilitates long-distance interactions between the individual students and student teams, and the groups of researchers and experts. Such interactions enable the peer-to-peer methods in education; the high school students learn the integrated STEM approaches to project implementation (PI). At the same time, utilization of the hybrid education methods preserves the emotional atmosphere of scientific cooperation during PI.

The extracurricular project-based learning used in our system allows students to adjust

quicjly the acquired skills to dynamic changes in technology and management over the transition to post-industrial development.

Utilization of Information and Communication Technologies (ICT) meets the goals of operative adaptation of the subject matter and education methods to the evolving realities of post-industrial societies, and preserves the integrity and synchronicity of education process within the spatially distributed structures of our extracurricular learning system.

ICT utilization within our system of the extracurricular program combines the project-based learning with the organization of the national contest of students' projects and facilitates cross-disciplinary approach to PI that motivates the students towards sustainability goals attainment.

Keywords: Management educational systems, Educational innovation, Non-formal education, Extracurricular program activities, Education for post-industrial development, Partnerships for education, Information and communication technologies, Distance learning

1. Introduction

Post-industrial development includes rethinking and modernization of public education to meet the needs of economic development at this stage, particularly, the needs related to empowerment and rising influence of the educated class (Toffler, 2004; Bell, 1999). Well-educated experts initiate and speed up technological innovation. The post-industrial trends in social and economic life dictate priorities for the public education sector, including increasing demand for adaptive approach to implementation of the innovative management technologies and solutions in a post-industrial society (UNESCO, 2015; Wals, 2011; Mochizuki & Singh, 2019). The priorities of public policy in education include: (a) increasing the range of acquired competencies required for development, management and implementation of scientific achievements; (b) creating incentives for young people, even at the early stages of schooling, for adaptation to ever-changing labor requirements and economic activities, development of capacity to integrate, or absorb, the rapid post-industrial social transformations.

The need to adapt the basic knowledge and skills to the dynamics of dissemination of technological innovations, to the rapidly changing the character of labor market, during the transition to post-industrial economy, creates the demand for innovative and non-formal educational solutions. Intensification of the education process facilitates the transition from the traditional subject-based education to inter-disciplinary learning. Such transition requires innovative approaches to education, and implementation of distant ICT in the methodology of extracurricular education. Such methodology merges the educational process and other societal functions together, and creates career development opportunities. Emergence of new types of ICT facilitates further research of the tools available for implementation of distant learning solutions in the flexible individual education programs in public education (Yermakov, 2020; Feraco, Resnati, FregoneseSpoto, & Meneghetti, 2021). The proposed innovative solutions will help to adapt the public education to the needs of the post-industrial economy in near-real time.

2. On Adaptation of Education to Post-Industrial Development

Transition to a post-industrial economy is characterized by rapid redistribution of the jobs among economic sectors and changing priorities of the labor market. The comparative economic advantages, accelerated development of services and implementation of knowledge-intensive innovative technologies by the service companies largely determine the directions of structural changes in the labor market. Economic advantages of being employed in the services sector are seen in the dynamics of the following indicators: relative share of employment in the services, the share of services in the GDP, and the basic education period it takes to become a college graduate (in years) that have been measured in the countries with different levels of economic development.

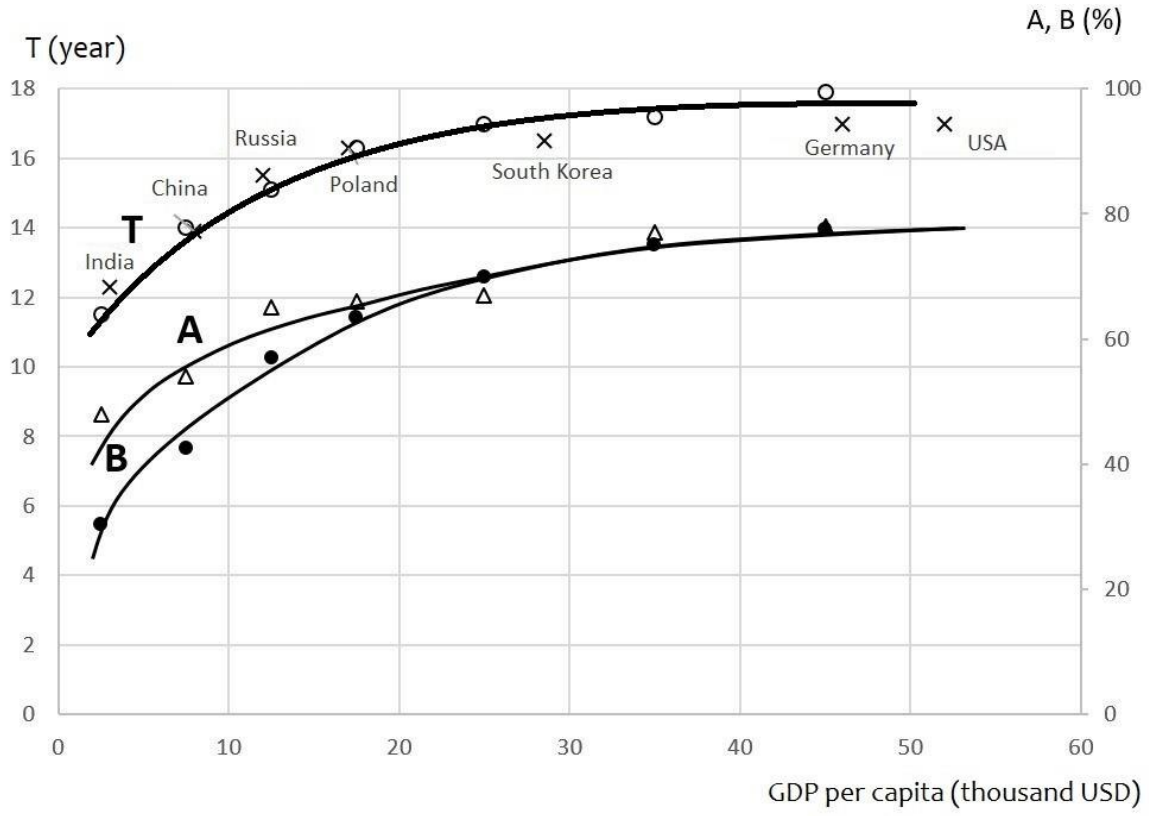

Figure 1. These curves smooth the scatterplots of the following indicators against per capita income in the selected countries: A - the share of services in the GDP; B - relative share of employment in the services; T – the number of years of basic education towards a university degree

Sources: Ranking of countries by duration of study, 2018, Share of employed in the service sector, 2019, GDP by economic sectors, 2018.

The economic development indicators shown in Figure 1 were averaged for the groups of countries that had per capita GDP within the respective intervals and the population above 10 million. The mean values of the per capita indicators correspond to the centers of those intervals.

The distribution of statistical data on the share of services in the GDP and the employment structure includes the countries that have undergone the period of transition to a post-industrial economy. This period begins when the share of services becomes dominant in the structure of GDP, and ends when the allocation of labor between services and industry reaches its equilibrium. That is, the moment when the share of the labor force employed in services becomes equal to the share of services in the GDP. The cross-sectoral redistribution of the jobs reaches the equilibrium point though a succession of turbulent iterations caused by competition of scientific innovations in the production of tangible goods (i.e., industry) and the production of intangible goods (i.e., services). About ¼ of the global population lives in countries where the GDP per capita ranges between 5 and 25 thousand USD.

A convergence of the distributions of the employment indicator and the income indicator along the economic development path (Curves A and B in Figure 1) is accompanied by growth in educational and qualifications levels of the economically able population. The most common and routine jobs such as those used in conveyor-type mass-production are being replaced by intellectual labor, which requires a long professional education. Such transition creates the demand for well-rounded multi-disciplinary education, early career-development and intensive capacity building in the areas of business organization and management. High expectations are vested in the growing importance of education. The current labor market trends show a growing demand for higher education: about 80-95% of all high school graduates in economically developed countries plan to enroll in higher education programs (OECD, 2020; Klyachko, 2020). Fast growth of the educational workload causes an increase in the length of the basic education cycle. This length of the education cycle therefore increases by 2.5 years on average during the period of transition to a post-industrial economy (Curve T in Figure 1).

The problem of the loss of competitiveness of early employment in the society which spends more and more time on education can be overcome by the implementation of extracurricular asynchronous modes of education that make use of distance teaching technologies. Extracurricular education programs employ the individualized (customized) education formats and they fuse basic education with the business activities. The demand for extracurricular education as a means of adaptation to post-industrial technological and social innovations is created at the early stages of basic education, mainly during the final years of high school when the student chooses a trajectory for further professional advancement (Martin & Joseph, 2016; Murphy, 2012).

3. Innovative System of Extracurricular Education and a Case Study of Distance Learning Practice in the Program

This system of extracurricular project-based education of high school students, combined with a national contest of students' projects carried out in the learning process, was developed in the Russian Federation. The general scheme is shown in Figure 2. This system was authored by a non-commercial organization (NGO) "Environmental Projects Consulting Institute" (EPCI) (Kosarikov & Davydova, 2021), and implemented in the format of a Society-State-Private partnership (SSPP, Figure 3).

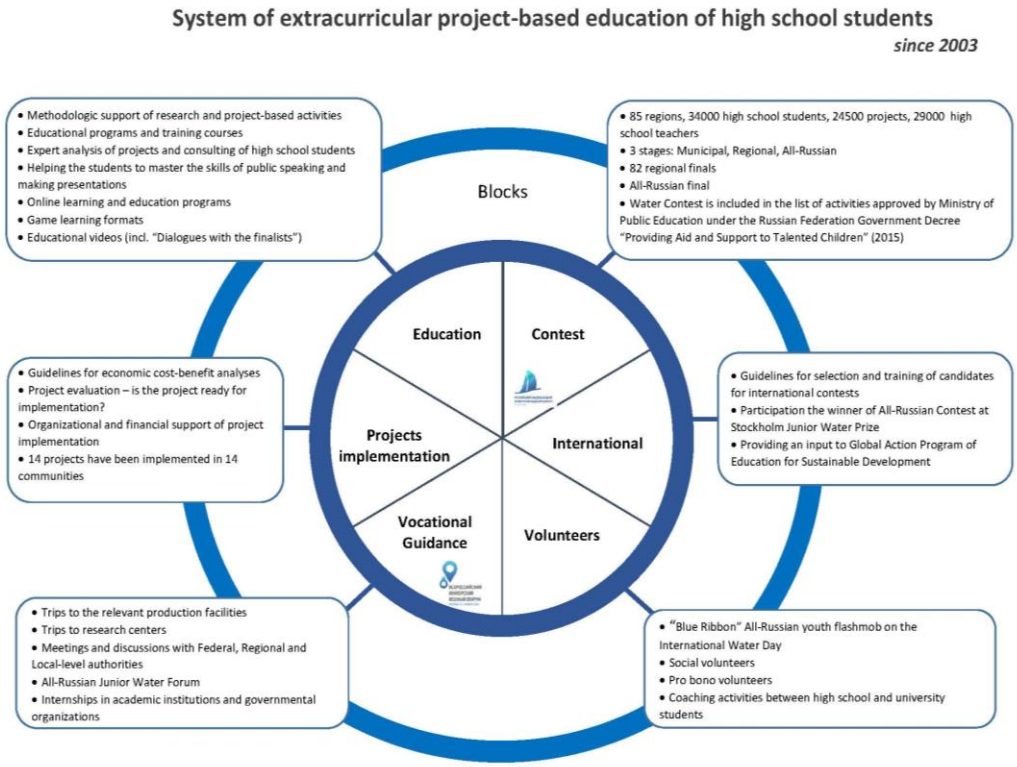

Figure 2. System of extracurricular project-based education of high school students

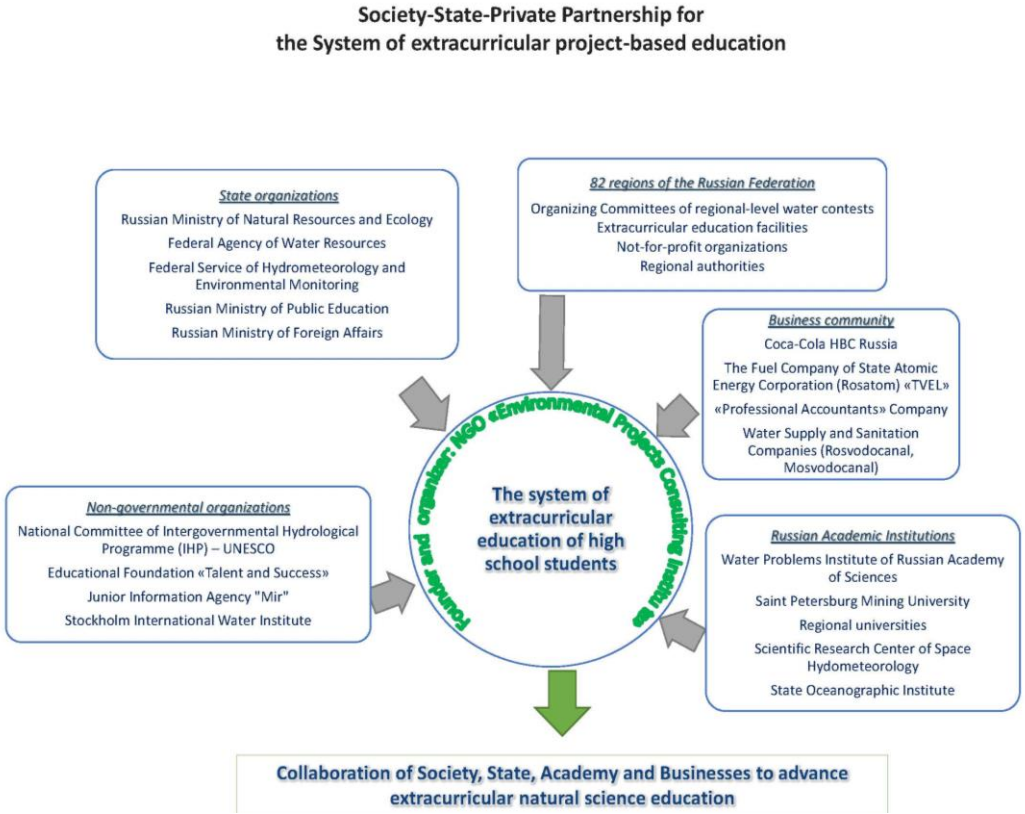

Figure 3. Scheme of the partnership for the implementation management of the system of extracurricular project-based education program of high school students

Under the SSPP arrangement, EPCI acts as a non-state public entity not bound by any governmental educational standards, and it manages a distributed system of extracurricular program education, controls the agenda and establishes the modes of interaction between the program participants and the EPCI regional representative offices. Such interaction takes place on the regional stages of the junior project contest and provides extracurricular education for high school students. The uniform procedures that govern the program are enforced by the network of regional representative offices that use the material and organizational resources of the regional departments of public education. The EPCI regional representative offices also cooperate with the higher schools, research institutions, and other regional-level state organizations.

This education network currently operates in all Federal subjects of the Russian Federation and spans the diverse and economically unequal territories of European Part of Russia, Siberia and Russian Far East.

In spite of the territorial fragmentation and the autonomy of the regional representative offices, the integrity of the distributed extracurricular education network is maintained by uniformity of the agenda (project topics), the vertically-managed regional stages of the Federal project contest. In addition this integrity is maintained by the standard distant learning technologies like the Zoom remote communication platform, which is widely used in Russia. The program participants also use other digital communication platforms supported by the regional universities and partners. A direct participation of academic advisors and project consultants in the field activities and/or laboratory experiments of the students remains an essential feature of the junior project implementation. At the same time, organization of the online lectures and master-classes of leading academic scientists and experts opens up new prospects. A combination of the offline and online teaching formats within the project-based education program attracts the students and can be effectively used at the contest phase (Davydova, Kosarikov, Kirillov, & Igumnov, 2020).

The main topics of students' research in the framework of the extracurricular education program evolved around the sustainable development agenda. The participants investigated a broad spectrum of technological and organizational solutions to enhance environmental and climatic stability, or reduce technogenic impacts on local and regional environments. A cross-disciplinary approach remains a guiding principle of this program and facilitates involvement of leading experts who work in a variety of scientific disciplines, national and regional research institutions and laboratories.

The students who participate in the extracurricular education program and the junior project contest acquire the skills of integrated approach to a particular research topic during project implementation (McDonald, 2016; Asghar, Ellington, Rice, Johnson, & Prime, 2012). The participants choose the divergent (nonstandard) solutions to the specific problems of sustainable development. The ability to innovate becomes their competitive edge that will be beneficial for their career development in any area that they are going to pursue in the future.

The stable functioning of our extracurricular education system is attained by combining the offline and online learning techniques. The high school students gain the basic knowledge

and research skills in the course of implementation of individual projects in the relevant fields of study, but the socialization of junior researchers does not happen this way. Their socialization is attained through the centralized online meetings where they discuss their works. The extracurricular education format relies heavily on the individual and independent character of the students' work, and facilitates their professional socialization. At the same time, the centralized element in the structure of the extracurricular education program creates the competitive atmosphere and determines another level of socialization, which might be called Social and Emotional Learning (SEL) (Jones & Doolittle, 2017). The website of our education program informs the participants about the schedule of centralized events. This website administers the online translations and receives comments. The remote information and communication technologies sustain the desired level of scientific discussions, which is an essential element of the project-based education of the high school students. The discussion forums successfully meet the goals of SEL, increase the competitiveness of the project contest, accompany both the centralized events (master-classes, objective-setting lectures, project selection and appraisal procedures) and individual project-based activities or consultations with peers.

The regional stages of the junior project contest promote coordination among the students and their supervisors, technical experts, and project consultants. The remote consulting support closely resembles 'coaching' because the consultations are inherently individual, and theoretical discussions lead to practical recommendations tailored to the students' needs. Individual learning schemes are 'desynchronized' because the consultations are being scheduled so that not to intervene with the professional activities of the peers. The distance learning of the high school students meets the criteria of 'peer-to-peer' education (Kopnina, 2012). The creative contacts of the students with the leading experts in the field facilitate the development of teamwork skills and innovative approach to project implementation. A combination of research-and-development practices, project-based solutions, the basic principles of the junior project contest, master-classes and workshops helps to implement the relevant goals of public education towards sustainable development in the adaptive learning sector (Rushton & Batchelder, 2012; Ahn, Weng, & Butler, 2012). The students' project topics usually correspond to the directions of research and development of the academic institutions where the project consultants and advisors come from.

A methodological correction of education practices during the pandemic (Strong-Wilson & Yoder, 2021; Sir John Daniel, 2020) only slightly affected the degree of involvement of the project participants and the level of academic excellence of the students' projects because of the personalization of project implementation combined with the organic nature of the remote consultations.

More than 60% of all completed students' projects (List of regional projects, Russian National Junior Water Prize, 2019, 2020, 2021, Finalists Catalogue, Russian National Junior Water Prize, 2019, 2020, 2021) considered the problems of environmental monitoring, built the databases of the local environmental indicators, or assessed the economic damage from unstable economic practices. These topics allowed the tracing evolution of the methods and approaches applied by the students in the course of project implementation. The development

of information and communication links increased the share of innovative solutions up to 20-25% of all proposed solutions in the aforementioned fields. The students typically proposed creative solutions, such as, introducing new chemical markers of environmental quality, new materials or methods for biological testing, including biomonitoring with the genetic engineering methods and DNA analysis. Software applications in remote sensing, utilization of drones that carry air- and water-quality monitoring sensors were proposed to monitor the changes in the state of the local environment. An increase in the share of the projects that proposed knowledge-intensive technological and designer solutions confirmed a general interest in the potential of the information and communication platforms or organizational capacities of PPP that bridge the gap between education and practice of professional project-based research. In this sector of junior projects, which constitutes about 20% of all submitted projects, we observed a wide variety of solutions offered in the areas of renewable power generation for emergency lighting, power supply for the monitoring equipment, mobile device chargers, an original design of a small-size tidal power plant with a MGD-generator. The technologically oriented projects developed the original coagulants and sorbents for wastewater purification; an installation for final purification of drinking water; and a micro plastic filtering device that used a ferromagnetic mixture.

About 15-20% of all projects belonged to the ‘organizational and humanitarian’ segment. These projects considered the excursions and education programs to study the local lore, the design of technical documentation for conservation of natural monuments and biodiversity, or restoration of recreational water reservoirs. The students who worked in this segment actively used various distance learning technologies for interaction with governmental authorities or pubic organizations.

Distance learning technologies can be harmonically integrated into education process. ICT potential can be effectively used to supplement traditional schooling with implementation of students’ research projects in the area of education for sustainable development (ESD). Distance learning technologies present opportunities for a hybrid online and offline extracurricular education, with one limitation: the preservation of conditions for group socialization. A social group of high school students should maintain horizontal links, emotional cooperation and competition, as these factors create the incentives for supplementary project-based education. A reasonable balance between online and offline education methods evolves during approbation of the alternative learning technologies used in extracurricular education.

The desirability of remote learning varies in the different stages of implementation of the junior project contest as a program of high school supplementary education. Surveys of the program participants and expert opinions showed that the effectiveness of the remote ICT methods crucially depended upon the initial level of involvement of the students. Traditional offline format and personal discussions were important during the project appraisal and evaluation stage. The participants and experts positively reflected on the use of remote learning technologies, while about 80% of the respondents supported the traditional offline format of the contest finals. At the same time, the respondents indicated that the interactive online panel discussions attracted new participants to the program, and enabled the

peer-to-peer contacts between the students and the leading experts in the particular field of study. The external audience of the broadcast events (master-classes, thematic discussions, expert evaluations at the final stage) reached 5-6 thousand people, which was by an order of magnitude greater than the number of actual participants of the junior project contest.

The need to preserve emotional involvement in the horizontal communications naturally limits the reliance on the remote learning technologies. One of the program goals is to contribute to the professional socialization of the project participants, which provides an incentive for the students to join and to stay in. The obstacles that limit the application of the remote ICT methods can be overcome during the centralized broadcast events that have a mixed format: the contestants and the experts meet personally in an auditorium, while their meeting is broadcast so that the remote viewers can participate in the discussions. A hybrid approach to organization of education preserves the emotional dimension of contest and cooperation, and harnesses the advantages of the modern SEL techniques.

4. Conclusions

The post-industrial trends in social and economic life dictate priorities for the public education sector, including increasing demand for an adaptive approach to implementation of the innovative management technologies and solutions in a post-industrial society

The most common and routine jobs such as those used by conveyor-type mass-production are being replaced by intellectual labor, which requires a long professional education. Such transition creates the demand for well-rounded multi-disciplinary education, early career-development and intensive capacity building in the areas of business organization and management. High expectations are vested in the growing importance of education.

A fast growth of the educational workload causes an increase in the length of the basic education cycle. This length increases by 2.5 years on average during the period of transition to the post-industrial economy.

The problem of loss of competitiveness of early employment in the society which spends more and more time on basic education can be overcome by implementation of extracurricular asynchronous modes of education that make use of distance teaching technologies.

The public-private partnership concept can be successfully implemented and managed in the system of non-formal education that in its turn relies on the remote ICT solutions and facilitates personalized approach to education through individual consultations between the students and their academic advisors. A social group of high school students should maintain horizontal links, emotional cooperation and competition, as these factors create the incentives for the supplementary project-based education.

The remote information and communication technologies offer valuable benefits for the education process, make it more sustainable and integrated, and meet the goals of the innovative system of extracurricular education program combined with the contest of interdisciplinary junior projects devoted to the preservation of climatic stability, ecological

balance, and sustainable post-industrial development. Remote learning builds the virtual bridges for participation of the juniors (project authors) in the research and development programs of the academic institutes and universities, facilitates the professional communication and creative teamwork of the students.

Integration of ICT in the structure of this system enriches the spectrum of available learning technologies for adaptation of high school students to the dynamic dissemination of organizational and technological innovations during the transition to the post-industrial development. The hybrid format of the activities within the developed system allows for harmonic inclusion of the remote learning technologies in the program that combines the project-based approach to education with the competitiveness of the national junior project contest.

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Biographical note

Alexander N. Kosarikov, Doctor of Economics, is a Research supervisor of the Environmental Projects Consulting Institute and Professor of the Russian Presidential Academy of National Economy and Public Administration. He has published over 200 journal articles and 15 books. He has used his experience of the leadership of a large city and region in his research activities. From 2000 to 2008 Prof. Kosarikov was a vice-chair of the Committee of Ecology of the State Duma (Parliament) of the Russian Federation. His main research topics are related to the sustainable development of urban agglomerations in the process of transition to a post-industrial economy. Key research areas consist of modernization of education in accordance with goals and dynamics of post-industrial changes. He is the Chair of the Nomination Committee of the Russian National Junior Water Contest and State Prize Laureate of the Russian Federation for science and technology.

Natalia G. Davydova, PhD, has been a Director of the Environmental Projects Consulting Institute since 1998. She has developed and coordinated all projects of the organization, incl. the Russian national junior water contest, institutional projects, environmental education and public awareness programs, integrated water resources management, etc. Natalia has developed and applied the principles of management for the specific system of extracurricular activities (ECA) of high school students in Russia and coordination of regional centers' activities within the system. ECA are recognized as good practices and included in the registry of Federal Ministry of Education. She has created an all-Russian "Society-State-Science-Private" partnership to raise effectiveness of extracurricular environmental education and to encourage youth's research and volunteer activities for environmental protection. She has worked to put students' projects into practice in local communities and developed vocational guidance for young researchers. She is a Russian Federation's Government Prize Laureate in a field of education.