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ABSTRACT

The post-industrial orientation of an economy towards professionals capable of developing and implementing innovative solutions determines the need for rethinking the goals of education and changing educational technologies.

Based on the analysis of the distributions of statistical indicators characterizing changes in national education systems in connection with the development of the economy, steady trends in the growth of the population's level of education and the duration of the higher education cycle, which goes beyond competitive expediency, are shown.

At the same time, the trends of increasing educational loads and informational saturation of education can be alleviated by modern opportunities for extra-curricular forms of education that are compatible with business activity and career development of a specialist.

A critical solution is the development of interdisciplinary integration skills in project-based activity within the framework of extra-curricular education that corresponds to the tasks of developing innovative directions in the economy.

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A critical solution is the development of interdisciplinary integration skills in project-based activity within the framework of extra-curricular education that corresponds to the tasks of developing innovative directions in the economy.

The stability of the functioning of the developed system of extra-curricular education for high school and university students, which has undergone a period of interregional scaling, is determined by several methodological principles oriented towards the psychology of the youth audience, including: the personalized nature of learning using individual educational cells; the use of emotional competitive elements related to academic support of project-based activities; the inclusion of hybrid forms of digital information and communication technologies in the educational process and the testing of the results of project-based learning.

Practical results make it possible to identify the effectiveness of the system's methodological complex for the entire period of academic advancement. In addition, it allows for using proven innovations for educational support at an early stage of a professional career.

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I. INTRODUCTION

Structural changes in the economy during the transition period to post-industrial development necessitate rethinking the tasks of modernizing education. Stability of trends in educational policy depends on the degree to which they correspond to the priorities of post-industrial labor and employment structures. Ensuring the flexibility and promptness of the educational response (i.e., making changes to the education system) to the processes of dynamic changes in technology and management occurring during the transition period determines the relevance of research aimed at maintaining the conformity of the acquired knowledge and skills to the needs of the economy.

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During the systematic transition to an innovative economy in the post-industrial stage, the significance of scientific achievements and technological and organizational innovations have increased and have become the main tools for economic development. These tools replace the resource contribution to the economy (i.e., the use of natural resources, including fossil fuels, as the previous economic driver). They are associated with a consistent increase in the education level of society and an increase in time spent on education. In the new economy, human potential creates innovations, and they ensure economic growth. During the transition period to the post-industrial stage, the development of the intellectual level and the improvement of professional opportunities take the leading positions in the public assessment of careers. The priority of modernizing education during the transitional period in the economy is the formation and development of a class of highly qualified specialists (Toffler 2004) capable of initiating and ensuring the implementation of post-industrial innovative changes in socio-economic development.

The innovative orientation of development in the post-industrial economy is associated with functional corrections to the main links of the educational system and an expansion of the range of knowledge and skills acquired through the learning process. Both factors are necessary for organizing and implementing the prompt transfer of breakthrough scientific research results into the real economy.

However, the possibilities of the educational strategy that ensures the correspondence of the qualification obtained during the learning process to the conditions of the post-industrial stage of economic development are limited.

Firstly, the consistent strengthening of the increase in the informational saturation of educational programs in the traditional hierarchy of basic education is limited by the acceptable duration of the learning period. Therefore, the importance of extracurricular programs that allow for the combination of learning with practical activity and the implementation of career goals is intensified in the configuration of the education system towards the goals and dynamics of post-industrial development.

One of the key tasks also becomes the practical use of the potential of modern distance information and communication technologies (ICT) in providing educational support for business activity. The use of the contemporary potential of ICT in project-oriented extra-curricular education allows for the individualization of learning, methodologically ensuring adaptation to the post-industrial dynamics of the implementation of scientific results at the early stages of acquiring basic knowledge: during the completion of school education and transition to the next stage of professional training. In other words, the start of a professional career during the extended education period should not be delayed, as competitive advantages may be lost. It is necessary to combine career and education, and this becomes a stimulus for the development of extra-curricular education.

In this article, we will analyze the experience of a distributed network for the extra-curricular project-based education system of high school students that we have created (Kosarikov, Davydova 2021).

This system is designed in a multi-sectoral format of public-state partnership (PSP) and is currently operational in all regions of the Russian Federation. 20-years of experience in this field allows us to evaluate the practical impact of the main methodological approaches, that were laid down on the basis of the system development, on the sustainability and effectiveness of learning. These approaches have undergone lengthy testing in regions that differ in levels of development and sectoral features of the economy. Hybrid options for extra-curricular education, combining classroom and distance learning, have been incorporated into the technology of the educational process. The possibilities of modern ICT have been utilized both for territorial distribution and for transferring developed methods of

non-formal extra-curricular education in schools to the next level of academic advancement in the university environment. Extra-curricular project-based education accompanies the period of basic qualification training when high school and university students receive interdisciplinary training simultaneously with the standard course of study. This allows for the prompt correction of acquired skills in view of the high dynamics of the changes in technology and management during the learning process. The system is based on the rules of mastering interdisciplinary integration methods. In the process of project-oriented interdisciplinary education, connections are created between the learner and the teacher. These are the elements of professional socialization. They make it possible to use the stability of non-formal educational interaction to organize horizontal, peer-to-peer (p2p) expert-educational support schemes for business activity at the early stages of career development. In other words, the developed system moves from "education for all" to individual education in a peer-to-peer format, where the student and the teacher become colleagues and exchange opinions, ideas, and project solutions, ultimately contributing to the development of the post-industrial economy.

II. THE INFLUENCE OF POST-INDUSTRIAL ECONOMIC DEVELOPMENT ON MODERNIZING EDUCATIONAL PROCESSES

The transition to the post-industrial stage is associated with several processes, including replacing natural resources involvement as the main driver of economic development and the increased importance of transferring scientific achievements to the economy.

At the same time, the scope and volume of technological and organizational innovation implementations are expanding. The growth of the innovative component of the economy during the transition to post-industrial development is related to the processes of modernizing education. These processes are aimed at expanding and strengthening the influence of a class of highly qualified specialists whose qualification corresponds to the tasks of developing innovative solutions and operational transferring scientific results to the technological sphere. Positive feedback loops are formed between the modernization of the economy and the requirements for the specialists' qualification level. Thus, through the sequential strengthening of the innovation component of the economy, economic growth drives an "educational spiral": people, who have received new education, change the economy, and then the new economy demands even more educated people.

Within the framework of the post-industrial economy, a closed cycle of events is being formed: economic growth through the development of innovations determines the need for specialists with a wide range of knowledge and integrative interdisciplinary skills that are necessary for the development and operation of new technologies. At the same time, the sequential expansion of the influence and growth of the scientific potential of specialists sets the direction for a new round of innovative renewal of technologies and the next level of qualification requirements.

The dynamics of economic growth during the transition to the post-industrial stage of development is associated with the constant strengthening of investment support for the education sector (Figure 1). The tendency to increase the overall level of education in post-industrial countries corresponds to the tasks of mitigating the consequences of intellectual inequality for the sustainability of post-industrial development. Such group elitism arises as a result of the increased leading role of highly qualified specialists. Society, in turn, seeks to maintain stability and avoid educational inequality by responding with an increase in the duration of education.

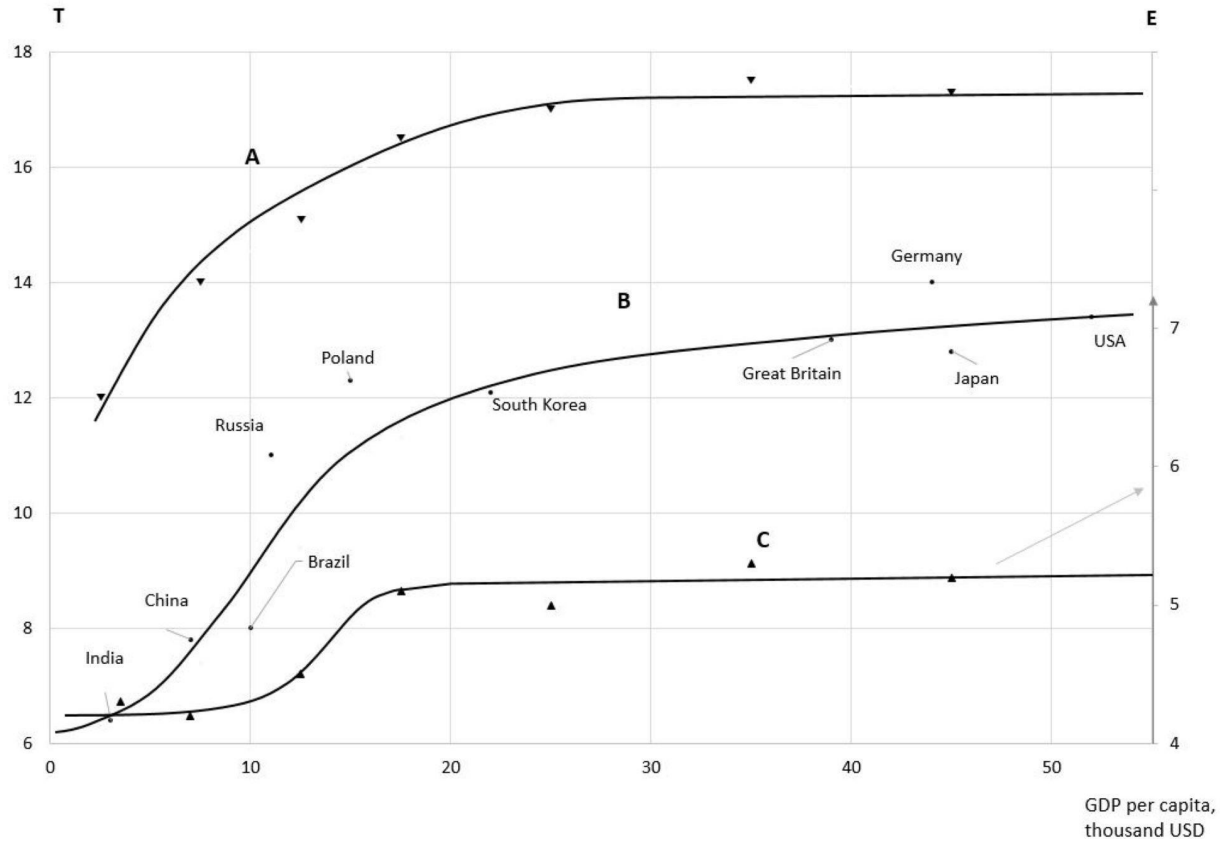

Figure 1

- T - duration of education, years;
- E - investment in education as a percentage of GDP;
- graph A - duration of education required to obtain higher education in countries with different levels of economy;
- graph B - the relationship between the distribution of average education duration (indicators of education) and the level of economic development;
- graph C - the relationship between education expenditure (as a percentage of the country's GDP) and the level of the economy.

The graphs in Figure 1 were obtained based on the analysis of the distributions of the statistical indicators of education duration, education expenditure, and the level of economic development for countries with populations over 10 million people (Ranking of countries by the duration of study 2018; World Bank indicators 2016, Economic data 2020; GDP by economic sectors 2018) . The data are oriented towards average values within selected GDP intervals (in USD per person per year at nominal value).

The averaging was carried out for countries with close indicators of per capita GDP. The size of the intervals for averaging was chosen with a step of 10,000 USD per person per year. Four groups of almost 40 countries with per capita GDP indicators of 0-10, 10-20, 30-40, and 40-50 thousand USD per person were analyzed.

Radical changes in the employment structure and requirements for the level of education and professional training of specialists occur during the transition period of the economy to the post-industrial stage of development. The transition period begins when the share of the service sector

reaches 50% of GDP and ends when the economic equilibrium level of industries that form the gross internal product is reached up to a GDP level of about 15...17 thousand USD/person/year). Here, equilibrium means achieving equal labor productivity in the leading sectors of the economy: there is a leveling of the average contribution to GDP of those employed in the service sector and those engaged in other sectors of the economy.

The relationship between the growth of average education duration and the economy' pace during the transition period is close to exponential (Figure 1, A) and is characterized by positive feedback. Upon completion of the transitional economic period, the indicators of the average duration of study/education of society in developed countries acquire a stable value for post-industrial development, which is approximately 70-75% of the duration of the entire cycle of study for higher education: 17 ... 17.5 years.

The level of education (as measured by the average duration of education) in developed countries largely corresponds to the post-industrial employment landscape, where over 70% of jobs in developed post-industrial countries are linked to innovative development in the service sector and oriented towards highly skilled specialists.

The modernization processes in education, the implementation of methodological innovations, the use of advanced information and communication technologies, and the growth of academic workload and duration are reflected in global trends of educational investment policy. The distribution of statistical indicators of education expenditure (Fig. 1, B) shows a characteristic step in the transition of financing to a level close to 5.2-5.3% of GDP within a narrow range of economic development (approximately from 13 to 15 thousand USD/person/year). In this range, the experience of the transitional period changes is fixed. This is followed by an increase in expenditures, which linearly accompanies economic development (Fig. 1, C).

The institutional correction of national standards for economic support of educational development (that part of GDP directed towards education financing) relies on accumulated experience from the transitional period and, therefore, is lagging and catching-up in nature. In other words, basic educational processes are lagging behind. It is necessary to introduce a mechanism that allows a person to adapt to rapidly occurring processes in technology and management.

III. ON THE PRACTICE OF EXTRA-CURRICULAR EDUCATION IN THE TRANSITION PERIOD

The system of extra-curricular education developed in our organization (Kosarikov, Davydova 2022) is not formalized by institutional regulations and it is aimed at training the project abilities of high school and university students. The system is focused on using integrative methods into the practice of applying scientific results in real economic sectors. The system's replication in the regions of the Russian Federation has led to the creation of a network structure of extra-curricular education distributed throughout the country, which is combined with a contest of school and university students' projects.

The organizational basis of the system is a multi-sectoral educational cooperation in the format of a public-state partnership (PSP). The members of the partnership are educational organizations, public organizations, municipal and state authorities in the field of education, as well as universities and scientific institutes. The territorial distribution of our regional network centers follows the administrative division of the country. Management of the system combines the vertical cycle of annual project contest organization - from planning to standardization of final procedures (Deming

2018) - with a focus on modern decentralization trends (Laloux 2014) in regional center management. The elements of regional decentralization are technologically efficient in solving the problems of network expansion and ensuring the sustainability of the functioning of regional centers of extra-curricular education.

The organizational and methodological integrity of the non-formal education system is ensured by an innovative combination of learning with the stages of a vertically organized students' projects contest. The inclusion of competitive elements in the educational process corresponds to the ambition and initiative of the school and university age periods and opens up opportunities for initial training in competitiveness in the field of intellectual activity. Within the system, we practice public projects' presentation and defense of the project's results with the remote participation of external audiences. Students go through several stages of municipal, regional, and all-federal competitive events. After completing each stage, a list of leaders is formed.

Through the practice of the system's functioning, it is demonstrated that basic school education provides the opportunity for transitioning from the traditional vertical study of basic disciplines to the comprehensive mastery of integration methods, including STEM competencies (McDonald 2016; Asghar, Ellington, Rice, Johnson & Prime, 2012) for managing project-oriented activities and the development of combinatorial, divergent project solutions. The framework of the general direction of extra-curricular project-based education - an innovation for ensuring sustainable development - determines *the thematic integrity* of non-formal learning in the conditions of organizational decentralization of management.

The extra-curricular format of the education system, combined with a national contest of the students' projects, and the openness of the teaching methodology for the broad use of digital information and communication technologies, enable the leveling of the influence of differences associated with the specific features of schools (Brunner, Keller, Wenger, Fischbach, Lüdtke 2012) including differences in the students' basic education due to geographical location, including remoteness from leading scientific and educational centers of the country.

Decentralization of the system management also leads to a shift in the thematic focus of the projects carried out during extra-curricular education toward local problem-solving. The themes of student projects are associated mainly with the tasks of active monitoring of local territories (EPCI 2019-2022). Thus, our system promotes the principle of "Think globally, act locally" simultaneously in the spheres of environmental protection and sustainable development and education for sustainable development. We note the general trend of applying integration approaches to problem formulating and solving within the research activities of high school and university students in the form of an increasing share of interdisciplinary projects:

- Using mathematical modeling,
- Applying digital technologies to adapt remote sensing data to the tasks of monitoring and predicting changes in local ecosystems and water bodies,
- Developing software elements of artificial intelligence that enable the forecasting of technogenic changes,
- Creating virtual reality reflecting the consequences of economic decisions for sustainable development.

The range of thematic areas in project-oriented learning reflects the possibilities of the system of extra-curricular education going beyond narrowly specialized learning. High school and university students choose project directions focusing on a wide range of educationally relevant issues for

sustainable development (Kopnina 2012; Rushton & Batchelder 2012). In the 2021-2022 academic year, a number of projects were identified as the most advanced based on competitive testing, with potential for technological implementation and use in professional scientific research, including:

- adaptation of remote space sensing results to assess the transformation of glaciers in the Central Siberian Plateau (Krasnoyarsk region),
- digital modeling of greenhouse gas emissions from bottom sediments in the Volga Basin (Republic of Tatarstan),
- use of magnetohydrodynamic effects for co-generation of electricity in tidal power plants in the Barents Sea (Murmansk region),
- modeling of adsorption-magnetic filtration of wastewater from microplastics (Samara region) and others.

The inclusion of the periods of individual learning in the structure of extra-curricular education and emphasizing the development of personal inclinations and abilities allows for the enhancement of the effectiveness of new information acquisition (Vainikainen, Hautamaki, Hotulainen, Kupiainen 2015; Watkins, Lei, Canivez 2006) and the expansion of skills of integrating scientific results with the target tasks of projects. The use of distance ICT learning removes geographic limitations in the interaction of system participants and creates feedback with leading specialists and scientific teams within the framework of PSP, which has a significant impact on the level of students' projects development.

The main burden of mastering integration STEM skills in project-oriented learning falls on *individual educational cells*, which include the project author, consultant specialists, and the learning organizer-teacher.

These individual cells are combined in the system into a horizontal peer-to-peer structure (Ahn, Weng, Butler 2013), which provides educational support throughout the entire period of extra-curricular education. The potential for the stability of feedback loops in the "student-consultant-teacher" chain, which is characteristic of individual learning (Henderson, Phillips, Ryan, Boud, Dawson, Molloy, Mahoney 2019; Azbel, Ilyushin, Morozova 2021), is projected onto the sustainability of the functioning of the p2p-network, formed from educational cells, at all levels of academic advancement: from high school students to university students.

Trajectories of Information Exchange and Clusters of Intensive Creative Interaction in P2P Networks.

Information exchange trajectories and clusters of intensive creative interaction within the framework of the p2p network are chosen by the participants-authors of projects independently, guided by the thematic focus of the project. The participants also use hybrid ones: remote and direct contacts, in the process of educational conferences and centralized workshops.

The closed/auditory format of discussions during the learning process and competitive procedures supports the majority of participants, around 80%, including project authors, experts, and pedagogical organizers of education, as per survey results. At the same time, remote interactive forms of discussions meet the conditions for expanding the interested audience and utilizing elements of peer-to-peer exchange. The external audience for interactive educational events, transmitted in real-time, usually exceeds the number of direct participants, ranging from 100-150 people to 5-6 thousand viewers.

The study reveals that the maximum level of using distance technologies is limited by the need to preserve the emotional component of horizontal connections and by the conditions for group

professional socialization of participants in the educational process. However, restrictions limiting the use of remote ICT are significantly mitigated by organizing event broadcasts in a mixed format. A group of direct learning participants, including project authors and experts in thematic directions/nominations, are present in the venue, while interested parties participate in discussions remotely.

The study shows that the solution to the problem of objective testing of the success of education (Paulsen, Valdivia 2022; Wang, Shute, Moore 2015; Sun, Shute, Stewart, Yonehiro, Duran, D'Mello 2020) in the format of educational support for the projects contest, is organically combined with the development of practicing skills for a public demonstration of knowledge, professional competencies and promotion of the project results in a competitive environment. The autonomy of project authors in choosing directions and in implementing project developments, demonstrating personal competence during competitive presentation and promotion of the project, elements of socialization, and belonging to a professional community that are typical for project activities, correspond to the age ambitions of the target audience. The methodological orientation towards the psychological needs of the students (Deci, Ryan 2012) enhances the attractiveness and sustainability of the developed system of extra-curricular education.

IV. CONCLUSION

The increase in the level of education in society during the transition to the post-industrial stage of development has a significant impact on changes in consumption priorities and demands for organizational and technological modernization. The level of education becomes a leading factor in the post-industrial transformation of the economy and employment structure.

During the transitional period, with per capita GDP values ranging from 5 to 17 thousand USD/year, the average duration of education increases from 7 to 13 years, and the requirements for the educational level of highly qualified professionals reflect a 40% increase in the average period of the educational cycle, estimated to be around 17...17.5 years. The emerging trend in post-industrial countries towards an increase in the average duration of education, which characterizes the level of education in society, up to 70...75%, meets the challenges of mitigating the socio-economic consequences of educational stratification.

Maintaining competitive advantages of an early experience of professional activity in the context of post-industrial growth of the duration of basic education highlights the importance of additional forms of education that are open to using modern digital ICT, and allowing for an effective combination of the educational process with academic and business careers. The absence of the necessity of institutional regulation of the correction of programs for non-formal extra-curricular education provides an opportunity for an operational, synchronized educational response to the post-industrial changes in employment structure priorities caused by inter-sectoral competition and dynamic dissemination of technological and organizational innovations during the transitional period.

Developed for a youth audience of high school and university students, the system of extra-curricular project-based education relies on the organizational potential of the multi-sectoral public-state partnership.

The main element of the learning process is individual educational cells, the format of which allows for the support of the participants' own project developments. An educational cell includes the student, who is the author of the project, a specialist-expert in the chosen project area, who is involved in the learning process within the framework of the public-state partnership, and a teacher-organizer of the training.

The individual cells that personalize learning are combined into a horizontal network of peer-to-peer educational cooperation. The stability of the educational cells and horizontal network connections is methodologically ensured by hybrid - face-to-face and distance learning formats - and by the use of modern digital information and communication technologies.

The methodology for transitioning from subject-based basic education to intellectual and expanded versions of STEM education includes a range of positions oriented towards meeting the primary psychological needs of the young audience, such as:

- The autonomy of choosing research and project directions,
- The competitiveness of the results of project-based learning and public demonstration of competence during competitive advancement (contest) of the author's project developments,
- The formation of elements of professional belonging-group socialization in the network of the individual educational cells.

The integrity of the educational system is maintained by combining learning with the vertical of preparation and conducting of a national contest of the students' projects and by the general thematic direction of projecting for the implementation of sustainable development provisions.

Personalization of learning using individual educational cells and the main set of organizational and methodological provisions of the project-based integrated education maintains effectiveness for the entire period: from completing high school to obtaining higher education. As our practice in applying educational innovations has shown, it can be used to support education in the early stages of a professional career.

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