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# Educational Activity of National Research Universities as a Basis for Integration of Science, Education and Industry in Regional Research and Educational Complexes

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**Abstract**

The present article addresses the issue of integration of higher professional education establishments, science and industry in Russia. The basis for collaboration of these institutions is national research universities with academic research establishments and different operational sites for the purposes of implementation of overall reform of education system in the Russian Federation. The strategic framework for integration of science, education and industry in modern society and main reasons and targets for improvement of their collaboration on the basis of new development paradigms of modern democratic society have been described. It is found that integration of science, education and industry based on higher education establishments is a multi-level process, which includes the development of international cooperation of global information medium, uniform educational space and use of different innovative techniques and methods of teaching. The article is based on the study of educational activity of two national research universities - Tomsk State University and Tomsk Polytechnic University, which serve as central integration platforms for Tomsk research and educational complex. Main directions of their work for improvement of educational activity aimed at intensifying the efforts of science, education and industry to increase the competitiveness of Russian innovation technologies have been explored in the present article. As the article highlights, Tomsk model of integration of education, science and industry at the present stage of its development shows real benefits for the economic development of Tomsk region.



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*Keywords:* universities; higher professional education; modernization; education; science; professional development; research; professional competence

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## 1. Introduction

At the present stage of development of post-industrial society the competitive advantage belongs to those countries and companies on the world arena that have successfully developed an innovative economic sector based on knowledge industry and high-production industry and the increasing role of human capital in all types of activity (Raagmaa, 2002). The main conduit of scientific knowledge in modern states is the system of education and a central place in the circulation of knowledge belongs to research and educational establishments. Therefore, cooperation of university with research institutions and industrial enterprises is becoming more and more important. This is a base for creation of powerful research and educational, scientific and industrial platforms, which become the engine of economic development.

In the 2000s in the Russian Federation a new, long-term innovation strategy of society and state growth, based on concentration of efforts of society, government, business and science for the development of new, competitive technologies and products have been promoted. In the field of higher education and science, taking into account international experience, one of the main priorities of the development is the integration of education, science and industry. This idea became the center for the development in 2013 of a new Federal State Educational Standard (FSES) of the third generation, which became more focused on promotion of research work of students. A new institutional form of organization of scientific and educational activities aimed at training of staff and addressing scientific problems raised by high-technology sector of the Russian economy was a newly created in Russia network of national research universities (NRU), which are the basis for existing regional research and educational and scientific and industrial complexes (Borobov, 2014).

One of such successfully operating associations is Tomsk research and educational complex, which created a unique model of integration of science, education and industry and provides for a sustainable economic development of Tomsk region and constant support of innovation activity (Investicionnyj pasport Tomskoj oblasti, 2014).

## 2. Literature review

Many Russian and foreign researchers are involved in the study of integration of science, education and industry. The founders of the study of economic effect of the integration of these institutions at the international level are R. Blair, D. Kaserman and R. H. Coase. For example, R. Blair and et al. *(*1983) show in their work how to increase business profit after production of goods under cooperation of business with university research projects. In turn, research of R. H. Coase (1990) shows clearly that in those areas where regional research and educational complex is functioning, there is a steady increase in the quality of human capital, which is the basis for generation of the "creative class".

Such researchers as K. Brockhoff et al. (1999) have been involved in the study of the content and general structure of the innovation process. The basis for their research is the comparison of different models of cooperation of science, education and industry, created in Europe, Asia and North America. The authors argue that the overall dynamics of the innovation process is higher in those countries, governments of which are purposefully engaged in supporting university research, providing its financial investments and infrastructure.

Historical issues of cooperation between science and industry have been investigated by J. D. Bernal and H. Fusfeld. In his paper J. D. Bernal (1953) examines the first cooperation of European and North American companies with universities and research institutions in the field of manufacturing of high-tech products. The author notes that acquired experience made a significant contribution in further development of capitalism in Europe and North America. H. Fusfeld (1995) in this research analyzes the activity of enterprises and their cooperation with the first research and educational center in the early 20th century. H. Fusfeld proves high efficiency of symbiosis of science, education and business and shows clear benefits for all participants of cooperation.

Of particular interest is the work of J. A. Schumpeter and G. Bechmann, describing special aspects of attracting investments during manufacture of high-tech product, created by research and educational complexes with the close involvement of business. Work of J. A. Schumpeter (1934) is of special interest. He identified the so called "waves of innovation" and justified movement from economic growth to economic development through innovation. He found out an important role of entrepreneurship and scientists, whose interaction creates new, previously unknown combination of production factors. G. Bechmann (2010) states in his research work that symbiosis of science,

education and industry in the contemporary society is the strength that determines social change and promotes economic development.

Having explored Russian model of integration of science, education and industry such researchers as L. F. Glushchenko et al. (2005) paid special attention in their work to the development of forms of integration of universities with research institutions and all levels of education system, including higher education establishments. In the research authors examine forms of integration of universities with research institutions and all levels of the educational system of Russia. Researchers have identified the main objectives of integration, among which: usage of results of university research, joint production of high-tech goods, strengthening material-technical and social base of universities. Research of R. G. Strongin et al. (2005) has highlighted the role of university science in the regions of Russia and its relations with industry. Researchers have found that national research universities in the regions have played a special integrative role as alma mater for the majority of participants of socio-economic and political life of the region. So, it is natural that universities in the region are the center of generation of information society; they solve problems of region development.

O. M. Baykova et al. (2010) raise issues of mutually beneficial cooperation of science, education and business as communities. Authors believe that the development of such relations is necessary to create a class of young and energetic managers in science and education aimed at cooperation with business. The research work of I. G. Salimjanova (2011) is dedicated to the role of national research universities as to an important component of the national innovation system. The author argues that it is important to create favorable conditions at universities for teachers, students and post-graduate students. International cooperation is the basis for creating favorable environment.

All researchers have found great potential in the Russian education system for creation of competitive research and educational complexes in regions of Russia. Thus, review of literature demonstrates that researchers created a powerful theoretical base for the study of different models of integration of science and education in Russia and identification of the role of universities in the process of their development. But problems of acquiring practical experience of activity of national research universities for creation of a regional model of integration of scientific, educational and industrial structures have not been covered.

## 3. **Objectives and methodology**

Objective of the present study is to analyze practical experience of performing series of actions by higher education establishments aimed at integration of scientific, educational and industrial structures and defining future prospects and opportunities for the development of higher education. Solution of the following issues is required for meeting the set objective:

1. Description of the main global models of integration of education, science and industry related to new paradigms of development of the information society;
2. Demonstration of special features and aspects of the process of integration of education, science and production at three levels of cooperation: inter-insitutional, national and regional levels;
3. Identification of the key factors contributing to the development of international integration of education, science and industry in research and educational complexes;
4. Consideration of the main directions of modernization of the content and format of the educational process in national research universities;
5. Definition of the role and place of scientific research in educational process in national research universities;
6. Identification of the role and importance of national research universities in promotion of research activities of students.

The study is based on analysis of the two universities – Tomsk State University and Tomsk Polytechnic University. These Universities play a primary role in training the staff for Tomsk research and educational complex and operation of its scientific, educational, research and industrial divisions related to implementation of current reform of the education system.

To achieve the objectives a number of general scientific theories and methods of knowledge have been used. One of the main theories used in the research was the theory of modernization, which is a leading theoretical technique,

explaining inhomogeneous development of individual society and civilizations. Russia belongs to the "second level" of modernization, which is characterized by the leading role of government in the development process and by the clash of traditional and borrowed systems of values. Developments of this theory allow us to describe a reforming mechanism of science and education system of the country related to introduction of new institutions and practices borrowed from West European and US experience of social development into a political and socio-economic system of the state. At the same time when elaborating the issue of the present study a systematic method has been used. It allows using abstract tools to approach modeling of complex, multi-stage processes, greatly simplifying the solution of a specific problem, without loss of completeness of the analyzed phenomena. Application of this method allows us to consider research and educational centers, universities, educational sphere of the country as a system, which is based on organization of actions, covering a specific type of activity, identifying patterns and relationships for the purpose of their more efficient use.

## 4. **Strategic framework for integration of science, education and industry in the contemporary society**

In the contemporary society the increasing importance of science and education and their connection to industry depends on the intensification and results of research, improvement of the quality of education and scientific and technical staff, commercialization of research, increasing the number of young people in the field of research and development. Meanwhile, there are global reasons for the changes of the role of science and education related to new paradigms of society development.

The first paradigm in the integration of education, science and industry is creation of universal information space. Information used in communication between people and in educational, scientific and industrial activities plays the main role in the contemporary society. Exchange of information in education, science and industry facilitates the acceleration of scientific and technological progress and rational use of its intellectual potential not only within one particular country but also for the whole world. Establishment of the system of continuous education is the second paradigm in integration of education, science and industry. Educational process throughout life has become a response to the changing times and global patterns. This tendency arises from the constant change in industry, development of new technologies and modernization of technology. The third paradigm of symbiosis of education, science, and industry is determined by interdependence of operating life of technology and training of staff (Jaffe, Lerner & Stern, 2005). The development of technology usually comprises the following steps: preparation of the project, theoretical test, production, amortization and write-offs. Each of these stages requires highly skilled professionals with a certain level of knowledge. The last and the most important paradigm is the request for the personnel and a certain level of specialists' qualification. In the contemporary society, only cooperation of education, science and industry can solve the problem of unemployment and the demand for staff.

At the same time integration of science, education and industry greatly influences the ways and methods of professional training of specialists. It is the merge of educational process with industrial and scientific activity, which facilitates the process of adaptation of the specialist to the conditions of future professional field. Interrelation of the set of disciplines, techniques and methods of teaching should promote a clear understanding of the future work of specialists. The process of globalization adds value to the creation of integrated educational space, which gives opportunities to a future specialist for self-realization within their qualification, regardless of the state and nation (Sabau, 2008).

The process of integration of education, science and industry can also be classified according to three levels of interconnection: inter-institutional level, which is the interrelation between different scientific, educational and industrial organizations and their subdivisions. The earliest forms of inter-institutional integration of science, education and industry were American Cooperative Research Centers (CRC), established at the beginning of the 70s (Bogomolov & Egorshev, 1991). The main objective of these centers was to manage mutual work between research universities and industrial enterprises. This partnership led to the development and implementation of joint research projects, which excludes duplication in solving fundamental scientific and engineering problems. From the 1980s Engineering Research Centers (ERC), integrating education, research and industry into a narrow professional field started functioning in the United States. They predominantly relate to the development of new technologies, mainly in construction and manufacturing industries (Nurutdinova, 2012). ERC activities at this time were carried out with

the strong support of the state since problems of scientific and technical nature cannot be solved even by the greatest monopolies of the United States.

The regional level of integration of education, science and industry are Scientific and Industrial Complexes (SIC). These are territorial associations of research and educational institutions and industrial organizations that work together to develop, test and produce different kinds of industrial goods and services. Scientific and industrial complexes are widely spread. Today, only in the Siberian Federal District of the Russian Federation there are about 166 complexes. At the national (state) level, there is a development of National Research Programs (NRP). The development and implementation of such programs involves the entire scientific and technological potential of the state. Now NRP has become the main instrument of the state educational and research and technology policies that promote scientific and technical progress. Universities and institutions generating scientific knowledge have become the platform for the stimulation of such developments (Saitov, 2004).

Nowadays one more level of integration of education, science and industry – cross-national or supranational – has been created. Today, this level has been reached only by advanced European countries and the United States, for which the development of research in higher education establishments and its incorporation into production together with leading research centers in the world is a priority. In general, we can identify a number of major factors contributing to the development of international integration of education, science and industry:

1. International academic exchange of students, post-graduate students and teachers, overseas internships, professional development of academic staff;
2. Organization and carrying out of joint inter-university research, exchange of scientific information, teaching technologies; joint publication of monographs and academic articles;
3. Lectures and seminars with the participation of international experts;
4. Construction of the international centers and branches of universities;
5. Employment of foreign citizens as teachers, development of mutual training programs, mutual preparation and implementation of advanced educational programs (Popova, 2006);
6. Development and delivery of courses for learning foreign languages;
7. International cooperation in the cultural and sports fields: holding joint competitions, Olympiads and tournaments.

Thus, in the contemporary society, the integration of science, education and production on the basis of higher education establishments is a multi-level process and influences all spheres of public life. On the other hand, it is a multidirectional process based on international cooperation, global information environment, integrated educational space, use of different innovative techniques and teaching methods.

## 5. **Main activities of Tomsk national research universities to promote the integration of science, education and industry**

Currently, scientific and educational complex of Tomsk region unites establishments of professional education, represented by 6 state universities with research institutions, branches of foreign universities, international educational centers and Tomsk scientific centers of the Siberian branch of the Russian Academy of Sciences and Academy of Medical Sciences.

During 1990-2000 in Tomsk effective innovative research and education infrastructure was built on the basis of programs of strategic development. It is represented not only by research and educational institutions, but also by offices for commercialization of developments established in universities and academic institutions, business incubators, innovation and technology centers, center for cluster development, special economic zone of the technical innovation type “Tomsk”. Currently, Tomsk research and educational complex provides for systemic support of commercialization of the results of research activity and creation of science-intensive business (Psah'e & Zinchenko, 2009). Two leading universities of Tomsk - Tomsk Polytechnic University and Tomsk State University with “national research university” status have become the integrating basis for innovative infrastructure of the region. Besides, in 2013 both universities were included in the list of 15 higher education establishments named as “leading universities” aimed at increasing the competitiveness of Russian high schools by entering into the list of top 100 leading universities of the world.

These statuses stimulate universities to improve efficiency of educational and research activities by integration of research and education, effective transfer of technologies into economy, carrying out a wide range of basic and applied research and training of the staff for high-technology sectors of economy in conformity with the main directions of science development approved by the Presidential Decree #899 dated July 7, 2011 (Ukaz Prezidenta Rossijskoj Federacii # 899, 2011). To reach this purpose in both universities a large-scale reform of their organizational structures has been performed, strategic research and educational development programs have been developed. In 2012-2014 in TSU and TPU science, education and industry interacted by 10 main areas:

1. Modernization of basic educational programs. Basic educational programs in Tomsk universities have been modernized on the basis of Federal State Standards of the 3rd generation and standards of TSU and TPU, prioritizing research work of students. In addition, since 2013 TPU has been involved in experiment for implementation in Bachelor's program a modular scheme of the organization of scientific activity based on preparation of creative projects on the topics of students' research. In addition, in 2011 TPU joined the world initiative of CDIO, the purpose of which is to define the requirements to the content of educational programs and parameters of educational environment necessary for training of engineers. The result of joining of TPU to the CDIO initiative was normalization of the standard of basic educational programs to CDIO standards.

2. Development of Master's and Postgraduate studies. An opportunity to continue education plays an important role in professional development in high-technology industry of Russia. Therefore, due to the need to improve the competitiveness of the educational programs and develop academic mobility, TSU and TPU have developed educational programs of double Master's degree along with standard basic educational programs of Master's. Well-known European universities with academic relations with universities in Tomsk have been chosen as partner-universities. Also, in both universities the content and focus of post-graduate programs have been oriented towards priority areas of science and technology of Russia.

3. Creation of the system of elite education. Generally this measure, applied to stimulate educational research activities of students has been used in TPU since 2013. Elite students have an opportunity to greatly improve foreign languages, participate in international conferences, and study in leading universities of Germany, Denmark and Great Britain. In addition, in 2014 TPU started to develop additional program of elite education by Master's degree program. Gordon Engineering Leadership Program at Massachusetts Institute of Technology (GEL MIT) has been chosen as a basic guideline, which implies a significant extension in academic mobility programs and Double Degree – educational programs with leading foreign universities (Otchjot o rezul'tatah samoobsledovanija dejatel'nosti NI TPU, 2014).

4. Development of academic mobility. In 2012–2014 Tomsk universities executed a number of actions to stimulate academic mobility of students and teachers. This policy resulted in the increased number of students from other universities and teachers and lecturers from academic institutions and other universities with internationally recognized scientific schools enrolled or invited for lecturing in TSU and TPU. At that the number of students of Tomsk universities, traveling to study to other universities under student exchange programs has significantly increased (the most popular among them is Fulbright Program).

5. Development of system of continuing professional education. Occupational retraining and continuing education program, implemented at the Institutes of Distance Education in TPU and TSU have been significantly upgraded. Universities have developed tens of new training programs for advanced training; about a quarter of them had been updated to meet the demands of the market and involved the participation of leading Russian and foreign specialists. For example, in 2013 TSU developed five network programs for training staff for enterprises that develop high-technology industry. Currently universities are actively implementing a Swedish model of continuing professional education, which is one of the most effective and is based on the international standard CQAF (Otchjot o samoobsledovanii dejatel'nosti NI TGU, 2014).

6. Creation of the system of monitoring of the needs of the labor market for highly qualified specialists and efficient employment of graduates. The center for employment of graduates executes such monitoring in TSU. Assistance to employment of students is performed by the Department of Internships and Employment in TPU. Both structural subdivisions provide for a connection between university departments and business enterprises through partnerships with enterprises, institutions and organizations in the field of training of specialists, industrial internships and apprenticeships and employment of university graduates.

7. Apprenticeships. TSU and TPU created the system of organization of all kinds of apprenticeships of students on the basis of cooperation between employers, students and teachers. At the same time there is a steady trend of sending students on apprenticeships to enterprises related to the topic of their research. The example of TPU is prominent in this respect. In 2014 the university entered into 1100 agreements with enterprises on apprenticeships of students. Activity of 40% of these companies is connected with an innovative sector of economy of Tomsk region.

8. Support of student research. Support and promotion of scientific activity of students is the main direction for enhancement of the system of higher education in Russia. Therefore, in 2012 TSU and TPU have defined main directions for undergraduate studies. Today important scientific results have been received in priority areas of science, technology and engineering in Russia. The system of university and regional grants for research students under the guidance of a senior scientific advisor has been developed. In addition, universities create an organizational structure for integration of scientific developments. This job is performed by R & D commercialization departments, intellectual property department, department for coordination of CCU (Center for Collective Use) and department for scientific and technical information in TSU.

9. Attracting students to the integration of scientific developments. Not only the development, but also the integration of students' research work is an important objective for modernization of scientific and educational spheres and integration of their developments in industry. Therefore Tomsk universities pay much attention to cooperation with industrial sites. For example, in 2013 TSU carried out an experiment for integration of a student's project at the site of "Tomlesdrev" (Tomsk) for the development of technology and production of low emission carbamide-formaldehyde resins for getting eco wood-based panels. The project got great commercial success.

10. Creation of "innovation zones". Innovation zone is an important element of innovation activities of the university, which allows creating communities in universities for practical incorporation of results of intellectual activity. Innovation zone of TSU in 2014 consisted in 38 enterprises, in 26 of which TSU has a blocking stake and 12 companies use intellectual property of TSU. As a result of TSU work, 5 small businesses have been created that are aimed at integrating the results of intellectual activities of the university: LLC Soyana, LLC Glitergo, LLC Gallium Arsenide Sensors, LLC Radio Vision, LLC Radioprotection.

11. Discovery and support of talented youth. In addition to traditional forms of support and stimulation methods of research and educational activities of students, universities have introduced a system of university grants and personal scholarships, TSU introduced the system of scholarships of the Academic Council of the university. An important area of support of talented youth is the incorporation of Tomsk University into work of Technological platforms, activities of which are aimed at accelerating efforts to create advanced commercial technologies, new products to attract additional resources to research and development areas based on participation of all stakeholders: business, science, state and civil society. For example, in 2014 TSU participated in 19 Technological Platforms, which have been divided into 12 priority science and technology development areas approved by the Governmental Committee for High Technologies and Innovations of Russia, while TPU participated in 24 Technological Platforms.

Thus, the activities of leading higher education establishments – national research universities to improve their educational initiatives is aimed at stimulating scientific work of students and incorporation of scientific achievements into industry. National research universities apply a wide range of actions to improve their operations and increase the competitiveness of Russian higher education on the international arena. At that positioning of Tomsk universities as centers for integrated territorial research and education has a real economic impact. In 2013, the contribution of Tomsk research and educational complex in gross regional product amounted to 7%.

## 6. Conclusions

In the contemporary society the integration of science, education and industry is carried out at different levels: inter-institutional, regional and national. Cross-national level has great prospects for the development in the Russian Federation since one of the objectives of the national research universities is the development of research and its incorporation into industry in cooperation with leading research centers of the world. Creation and actualization of new technologies and scientific developments based on national research universities will allow to create a base of mutually reinforcing resources and competences to meet the increasing competitiveness of the Russian Federation

and implement joint international projects and programs in the field of education, research and innovation that will lead to the establishment of a system, characterized by greater stability and efficient functioning and development of all participants of the cooperation. A good addition to the already achieved results will be an introduction of new State Educational Standard 3+ (FGOS 3+) to the practice of higher educational institutions, which provides for agreement of results of studying among universities and demands of employers. This will certainly add value to the development of international integration relations between Russian and leading world universities.

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