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PITFALLS AND DRAWBACKS IN ENGINEERING EDUCATION IN RUSSIA

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The financial and economic crisis of 2008-2009 was the first call, which was to make the Russian society to focus on important issues, one of which is the quality of education as a basis for creating and sustaining an innovation ecosystem. Investment in education and the development of the necessary competencies are crucial in improving the competitiveness of the country: these are the competences of graduates that determine the potential productivity of the territory. Russia is facing the challenge of creating the type of economy that would enable attracting highly educated and skilled workers. This initiative is reflected in the federal document - the Conceptual of the Federal Action Programme for the Development of Education for 2016-2020 [1], which determines the quality and competitiveness of the Russian education as the prerogative of the state policy. The paper describes the current state of the educational market on the territory of the Bologna process members. It provides a comparative analysis of the effectiveness of the system of higher education in Russia with countries leading in the Global Innovation Index. The authors determined the range of problems associated with the 'insufficient effectiveness' of the educational system in Russia. Moreover, the authors proposed the view for establishing the policy aiming at development of innovative ecosystem.

Key words: Higher educational institution; Effectiveness of educational system; Inovative ecosystem, Economics of education; Innovation policy

INTRODUCTION

Socio-economic and political transformation in Russia predetermined the policy in the sphere of higher education. Under the new Federal Law "On Education in the Russian Federation" dated 29 December 2012 [2] higher education institutions were endowed greater autonomy in the development of courses from the "optional" part, which can be determined by each university independently. In addition, the government raised a question of improvement of quality and attractiveness of higher education. To implement this idea there have been developed indicators for monitoring the activities of higher education institutions in order to assess their performance and to restructure public educational institutions that are regarded as inefficient.

The state system of quality assurance, which was mostly limited to supervisory activities, ceased to respond to market demands. There was a need to create an alternative system of independent quality assessment. Government of the Russian Federation, along with the national associations of employers, leading universities, Russian Academy of Sciences and international experts have prepared proposals for public accreditation of educational programs of higher education, in the first place the program in the field of economics, law, public administration and sociology.

Today the system of higher education in Russia is changing, due to a number of prerequisites: Russia's accession to the Bologna process, which led to a change in the legislative and regulatory framework, a reduction in government funding, and increased industrial sector pressure on the quality of the results of training graduates of educational programs. The system of higher education will have to work on convergence with the sphere of labor, which should be based on improving the quality of educational programs that reflect the real needs of the socio-economic environment of the territory. The degree of effectiveness of the implementation of this process in the future will determine the innovative economy of the territory.

PROBLEM, STATMENT AND METHODOLOGY

The objective of this work is to study the factors that determine the effectiveness of the educational system and the definition of ways to manage the effectiveness of educational system to sustain and develop an innovative ecosystem. To achieve this goal it will be essential to carry out a comparative analysis of educational systems between Russia and the countries-innovators, as well as to identify factors that contribute to improving the effectiveness of the educational system.

The theoretical and methodological basis of the research was the applied and fundamental work of scientists in the

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field of innovation theory and the role of universities in determining the innovative strategy of the territory. This study analyzes data from three main sources: reports on the implementation of the Bologna Process through 2017, annual reports prepared and published by Cornell University, INSEAD Business School, and the World Intellectual Property Organization (WIPO) and the reports of the expert panels on the compliance of educational programs standards and quality assurance guidelines.

The reports published for the Education Ministers' Conference of the countries of the Unified Higher Education Area (hereinafter EHEA) made it possible to carry out a comparative analysis between the levels of public financing among the Bologna process members, identify the countries with the highest indicators and identify the countries that invest the most in maintaining and development of R&D. The annual publications of WIPO and others published in the rating of countries with the highest innovation index allowed to identify participants with the most favorable institutional conditions for the development of the innovative potential of the territory.

The material is supplemented with information obtained from reports on the results of external panels of higher education educational programs conducted by the Autonomous Non-Profit Organization “National Center for Public Accreditation” (hereinafter NCPA). Reports are the result of conducting 176 examinations, in more than 25 educational institutions of higher education. It is worth noting that the educational organizations were not selected in any specific way, the evaluation was conducted according to their voluntary application; while the geography of universities is very extensive and includes at least one educational organization from each of the eight federal districts of the Russian Federation .

DATA ANALASYS

The foundation of the innovation process is the human factor, related to the creation, implementation and further use of innovations. According to the annual report "Global Innovation Index" (GII), which is jointly produced and published by Cornell University, INSEAD business school, and the World Intellectual Property Organization (WIPO), today there are a number of countries that for several years have been leading among countries participating in the global study. These countries (Table 1) are seen as initiators and leaders of innovation activity. The main factor determining the country's innovative capabilities is human capital, directly related to innovation activity. Other factors: technology and capital, which influence the formation of innovative processes, also correlate with the human factor [4]. Therefore, the availability of a quality education system is crucial for creating the basis for an innovative economy. There are several ways that countries can grow talented people. First, each nation seeks to create a social infrastructure: schools, colleges, educational and research organizations - where the main goal is to increase the level of knowledge of the population in various technical and humanitarian fields of science. Secondly, countries can attract talented human capital from other parts of the world, creating certain incentive mechanisms, subsequently using such workers in various innovative activities [5]. Today, the example of the country with the best effective infrastructure and normative base for international recruitment is the United States, which managed to build an innovative ecosystem mainly by attracting the best "brains" of the world. The success of the United States is not only in the ability to effectively recruit scientific innovators, but primarily in the fact that the existing ecosystem is favorable for the implementation of innovative ideas and nurturing entrepreneurs.

Today innovations ensure a steady growth of the coun-

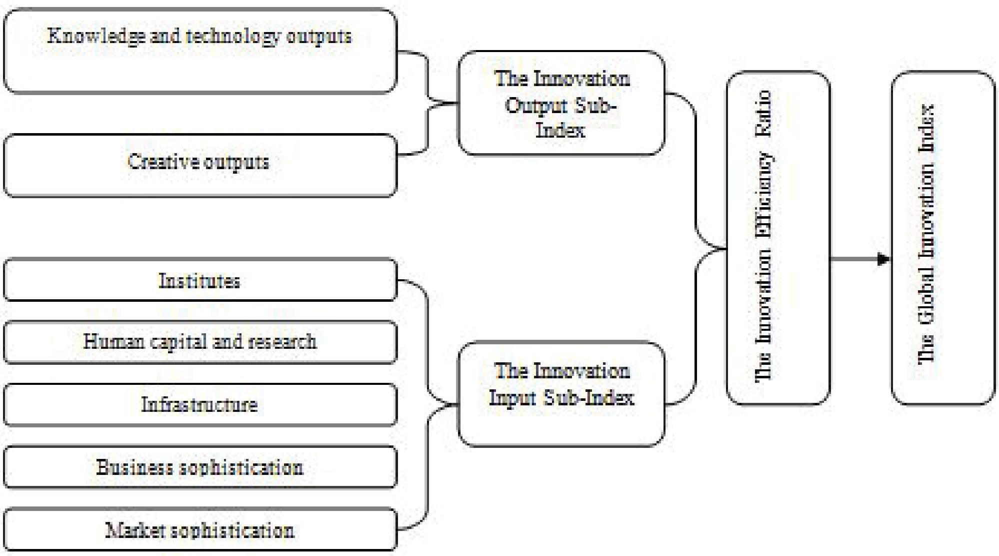

Figure 1: Conceptual map of the Global Innovation Index, 2017

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try and determine the role and place of the player in the market of goods and services. The actors making their contribution to the creation of an innovative ecosystem of the country are educational and scientific institutions, government organizations, infrastructure, markets, financial institutions, etc. [6] The Russian Federation with a multi-million population has a high potential, which makes it possible to create unprecedented opportunities within the country to create and support an innovative economy.

Let us consider in greater detail the issue of the formation of the market of educational services in the countries participating in the Bologna process. According to the report on the implementation of the Bologna Process for 2015, the structure of the EHEA is diverse. Educational organizations can be academic or applied; may be private or public, depending on the main funding item; other characteristics may also be used to determine the type of institution. The number of universities varies in different countries. The countries with the least quantitative indicators are Montenegro, Great Britain and Serbia, where this value ranges from 11 to 20 universities. The next group of countries, where the number of universities varies from 70 to 90, is represented by the Czech Republic, Norway, Spain. Seven countries have in their structure of higher education from 101 to 200 universities. A small group of four countries are leaders in the number of educational organizations: for example, in France this figure is close to 300, and in Germany and Poland it exceeds 400. Well, the indisputable leader in the number of educational organizations is Russia, with a number of educational organizations, exceeding 900 universities [16-20].

Table 1: Top-10 GII countries compared to Russia, 2011-2017

YEAR		2011	2012	2013	2014	2015	2016	2017
Country	Switzerland	1	1	1	1	1	1	1
	Sweden	2	2	2	3	2	2	3
	Singapore	3	3	8	7	6	7	7
	Hong Kong (China)	4	8	7	10	14	16	19
	Finland	5	4	6	4	5	8	6
	Denmark	6	7	9	8	8	6	10
	USA	7	10	5	6	4	4	5
	Ireland	8	9	10	12	7	10	8
	The Netherlands	9	6	4	5	9	3	4
	UK	10	5	3	2	3	5	2
	Russia	56	51	62	49	43	45	48

There has also been a significant increase in the volume of higher education. According to the data for 2011/2012, the number of students enrolled in undergraduate and graduate programs exceeded 37 million. The indicator of students enrolled in postgraduate and doctoral programs (2.7% of the total number of students) remains insignificant. The volumes of higher education systems in 47 countries reflect the demographic conditions of each country. The student population will also be affected by other attendant factors: the number of people meeting the established criteria (i.e., an adequate level of qualification for higher education); the effectiveness of the implementation of public education policies; existing alternatives in the labor market; the cost of training and the potential for wage growth at the end of the university; duration of studies on higher education programs. The total number of students varies from 960 in Liechtenstein to 7.5 million in Russia. The number of Russian students is more than a fifth of the total volume of this indicator.

Data on the volume of public spending on higher education are of great interest [12]. According to Eurostat and Eurostudent 2011 (Eurostat & Eurostudent 2011), one of the indicators of the volume of public funds for education is the percentage of government spending on GDP. The lion's share of the EHEA countries invest about 1.3% of GDP in universities. Annual government spending is the highest in Scandinavia (2.4% of GDP in Denmark, 2% of GDP in Sweden). Countries with the lowest indicators for this indicator are Slovakia, Croatia, Romania, and Bulgaria. The data presented show the overall picture of the state's expenditures taking into account the costs of ancillary services and R&D. While the costs of ancillary services may be insignificant and inconspicuous in the total amount of funds allocated by the state to higher education, part of the R&D budget can reach 46% (UK) and even reach 49% (Switzerland). A logical question arises: can investments in higher education guarantee the growth of the country's innovation activity, thereby determining its place in the top 10 of the “Global innovation index”? The answer becomes obvious, it is worth comparing the data of two independent studies: the annual reports of Cornell University, etc. and the reports of the Educational, Audiovisual And Cultural Executive Agency (EACEA). There is no direct correlation between the expenditures of the state on education and the country's innovative ecosystem. The United Kingdom is the best example, which during the last 4 years shows the growth of the economy and by the end of 2015 provided the 2nd place in the GII, while according to Eurostat, public spending on education in this country is among the lowest. The conclusion can only be as follows: the growth of an innovative economy is possible provided that there are positive changes in the system of education, favorable conditions for interaction between universities and the business community, effective forms of interaction of innovation actors with external partners, etc.

Table 2: Quantitative characteristics of students in countries-innovators and Russia

Country	Population (mln. people) 2012	Number of students (thou. people) 2012	Percentage of students (%)
Switzerland	8.2	104 003	1.268
UK	63.5	2 495 789	3.93
Sweden	9.6	453 328	4.72
The Netherlands	16.8	793 678	4.72
Finland	5.4	308 924	5.72
Denmark	5.6	275 009	4.91
Russia	142.5	7 983 111	5.6

Table 3: Share of graduates in engineering sciences, %

The rating of the country “The percentage of graduates in natural sciences”	Country (place in a global rating)	% of graduates in natural sciences
50	Switzerland (1)	20.85
39	UK (2)	21.85
16	Sweden (3)	27.19
85	The Netherlands (4)	14.42
14	Finland (6)	27.56
46	Denmark (10)	21.24
13	Russia (48)	28.11

This assumption is confirmed by the world ratings on the innovation index, presented in the annual reports "Global Innovation Index" (GII). Published for the first time in 2007, the report underwent a number of changes. For eight years GII came out on top and today it is an effective tool of comparative analysis, representing a horizontal section of innovative processes in developed countries and emerging market countries. The report is interesting because the authors did not confine themselves to the traditional indicator of innovation activity, such as the level of R&D. GII makes it possible to assess all the factors that determine the innovative activity of different economies. The calculation method is based on 79 indicators, distributed according to two main sub-indeces: the sub-index of innovation costs and the sub-index of innovation results [2]. The sub-index of innovation expenditures reflects the state of the elements of the national economy and has five main groups: institutions, human capital and research, infrastructure, market sophistication and business sophistication. The sub-index of innovation outpus reflects the level of cost efficiency of the national economy; is calculated by two main groups: knowledge and technology outputs and creative outputs (Figure 1). For eight years the conceptual approaches to defining the driving forces of innovation have changed. The development of the concept can be traced from the title of the annual reports. So the report of 2014 was titled “The role of the human factor in the development of innovations”, thereby emphasizing the key importance of human capital in creating an innovative ecosystem. The 2015 report "Effective Innovation Policy for Development" expanded the notion of innovation and emphasized the importance of institutional changes to achieve results. Today the difference between developed and developing countries is rapidly declining. It is worth mentioning China with its pace of economic development to understand that more and more countries with an income level above the average exceed in some indicators the costs of the countries of innovation leaders. We realize that simple introduction of technologies is not enough to support and develop innovations: the strategy of innovation state policy to reach the level of high-income countries will play the decisive role in this issue.

Table 4: Country's rating, according to the indicator "Researchers"

The rating of the country "Researchers"	Country (place in a global rating)	The indicator value (number of researchers per million)
12	Switzerland (1)	4,495
19	UK (2)	4,107
6	Sweden (3)	6,508
15	The Netherlands (4)	4,315
3	Finland (6)	7,223
2	Denmark (10)	7,271
27	Russia (48)	3,084

What indicators should be improved to compete with the leaders? And most importantly what should be the next steps to improve the innovation policy of the state?

Let us turn to the results of the Global Innovation Index from 2011 to 2017.

According to the latest report for the past five years in the top 10 there is a certain stability: Switzerland, ranking the first for the last five years. The increase in innovation was shown by the UK, which managed to change its position from the tenth in 2011 to the second in the last two years. Table 2 clearly shows the movement of the ten leading economies over the past five years, but the composition remains the same: Switzerland, Great Britain, Sweden, Netherlands, USA, Finland, Singapore, Ireland, Luxembourg (9th place in 2015) Denmark. Russia also managed to improve its performance, so the best the country achieved in 2015 (43rd place), breaking the fall of 2013 (to 62 positions). It is also worth noting that during the existence of the rating, positive qualitative changes in Russia's economy took place. According to the World Bank [7], overcoming the crisis of 2008-2009, Russia in 2013 changed its status from a country with an income level above the average for a state with a high level of GNI per capita. Today, the GII numbers 141 countries, 48 of which represent the economy of countries with a high level of GNI, Russia closes this list according to the results of the year 2017.

Table 5: Country's rating, according to the indicator "Hirsch's index"

Country (place in a global rating)	Country's rating, according to the indicator "Hirsch's index"	The indicator value
Switzerland (1)	9	629,0
UK (2)	1	934,0
Sweden (3)	11	567,0
The Netherlands (4)	8	636,0
Finland (6)	18	407,0
Denmark (10)	14	476,0
Russia (48)	21	355,0

We return to our main question and consider the position of Russia on such indicators of the innovation expenditures sub-index as human capital and research, as well as the sub-index of innovative output in knowledge and technology. Both sub-indeces are the most interrelated indicators, one of them will refer to the quality of educational services, while the second will reflect the effectiveness of this market. Within the framework of the GII report, quality is understood as a complex characteristic describing the number of graduates in the field of engineering sciences, the total number of students studying at all levels of education and international mobility. In the field of research, the importance of the number of employees engaged in development and innovation is emphasized, the costs of the state and private companies are needed for R&D, and also the rating of the country is important, according to the QS World University Ranking. And we are comparing these data for the Russian Federation with the data of Switzerland as a leader in innovation, the UK, Sweden, the Netherlands, Denmark, Finland, since all these countries regionally represent Europe, belong to countries with a high level of GNI per capita, and are participants in the Bologna reforms . Since the countries vary greatly in population, therefore, the number of students should be viewed as a percentage of the total population.

As much as one can consider, Russia has very favorable conditions for the realization of academic potential. The percentage of students enrolled in undergraduate and graduate programs (until 2014, postgraduate programs were not included in the cycle of higher education programs) is quite high and only Finland is ahead of Russia with an indicator differing by 0.12%. However, the decisive will be the importance of the number of graduates of programs that have been trained in the natural sciences, engineering, and construction disciplines (calculated as % of the total number of graduates). The information presented in Table 3 states that Russia managed to significantly bypass such countries as Great Britain (39), Denmark (46), Switzerland (50) and Netherlands (85) by this indicator. Russia lost a few points to Finland and Sweden (14th and 16th places respectively).

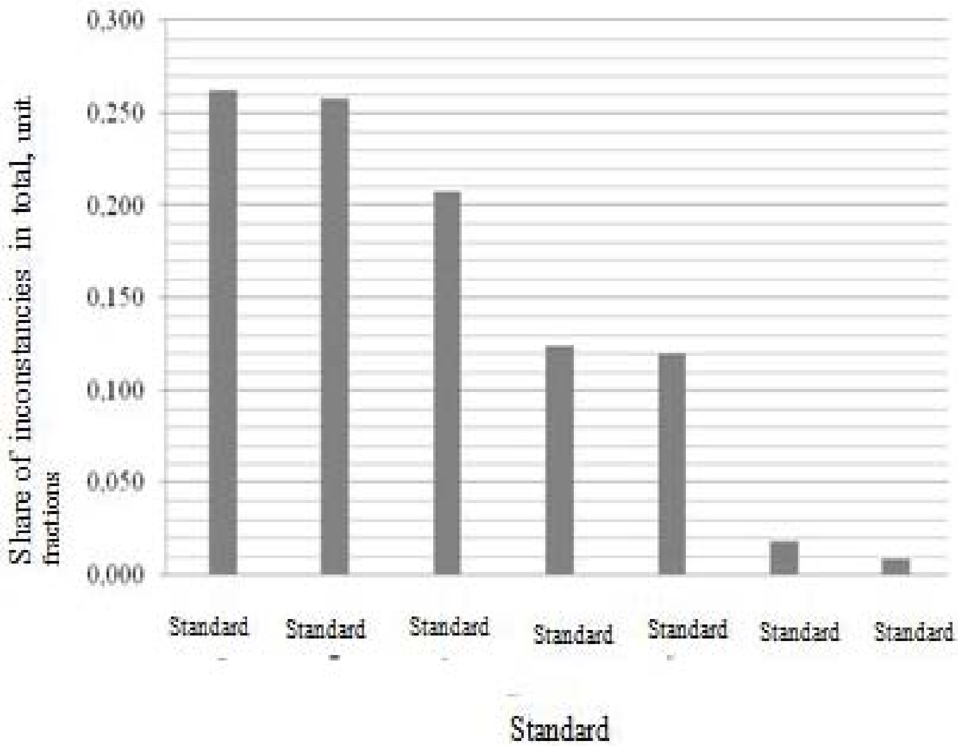

Figure 2: Pareto Chart

Almost a third of all graduates of educational organizations of Russia are trained in engineering programs, programs in the field of construction and production. Given the size of the country and the total number of students, the figure is indeed impressive. These are graduates who should make the greatest contribution to the development of an innovative ecosystem. It is also worthwhile to turn to data on researchers who are employed in science-intensive areas of production. Russia is much inferior to all of the above countries. The best results are observed in Denmark, followed by Finland, Sweden, Switzerland, the Netherlands and the United Kingdom. This list closes Russia. However, it should be noted that the indicator is not bad and according to the general list, Russia is at the level of Hong Kong (China), the Czech Republic, Lithuania and Slovakia.

Any research is carried out with financial support from either the state or private business investment. It was assumed that the costs of research development will significantly decrease after the 2008-2009 crisis years. The trend could be exacerbated by the fact that, even after returning to the previous level of financing, innovations will take time to implement, thus the growth rates of innovative development can be slowed down for at least five years. Data from the 2017 survey showed that countries managed to reach the pre-crisis level, and some did not reduce the level of investment and even exceeded it. Nevertheless, many developed countries have shown a decline in gross domestic expenditure on R&D. The main percentage of reductions occurred in the private sector, when, after experiencing the consequences of the crisis, firms had to choose areas for investment (data on the indicator gross internal expenditures on R&D were given above).

Outside the quantitative indicators comes the notion of "quality of innovation", which in the report of the GII is determined through indicators of the effectiveness of the activities of educational organizations. Sub-index " knowledge and technology output" most accurately reflects the effectiveness of higher education. This index is calculated based on the following indicators: knowledge creation, knowledge impact, knowledge diffusion.

The data on employment in science-intensive industries are of interest. That is, did the state succeed in finding employment for graduates, on whom public money was spent? And the main question here is: what do these scientists produce? How many articles were published? What is Hirsch's index? Have patents been filed and how many of the patents have been approved? All these issues should be considered through the prism of public-private partnerships, which in practice means a high level of effectiveness of higher education, a high level of cluster-university development, and a sufficient degree of commercialization of scientific developments [23] In terms of the number of the articles published with the public funding, Russia ranks 74th, which is inferior in this indicator to the countries-innovators. The result of the Russian Federation is comparable to the results of countries such as Rwanda (72), Pakistan (75), Botswana (76). It also takes into account the ignorant indicator that reflects the quantitative characteristics of a country's productivity, based on the total number of publications and the number of citations of these publications - the Hirsch index. Data for each country are shown in Table 5.

Even though Russia is included in the top 25 countries with the highest indicators, the difference between the leader – the Great Britain and our country is striking.

It is possible to draw a preliminary conclusion that the problems of the quality and effectiveness of education go beyond the limits expressed by quantitative data on students, published articles and the citation index. Obviously, one should take into account the level of business development and its willingness to incur financial costs, understanding that investments will be long-term investments; an indicator of the attractiveness of education for foreign investments will also be important.

In the framework of the study conducted by the group presenting the results in the report of the GII, no special calculations were made that allowed to assess the degree of development of collaboration ties between educational organizations and business. A survey was conducted among representatives of business structures and the academic community, during which a simple question was asked: “To what extent has the relationship between science and industry developed in your country for the purpose of R&D? Please, evaluate this parameter on a scale of 1 (links not established) to 7 (links are developing intensively).” The parameter determining the attractiveness of investments was calculated as the percentage of foreign investments from the total amount of gross domestic expenditure on R&D.

The subject for discussion in Russia should be questions regarding the development of public-private partnership and the attractiveness of the sphere of science and education for private investment. By these parameters, Russia (3.64) is almost twice as low as the leader of the rating of Finland (5.97), which also failed to realize the potential by 100%.

RESULTS ANDDISCUSSIONS

The weak development of partnership between universities and the business community is also evidenced by the data of the reports prepared as a result of the procedure of public accreditation. The analysis was subjected to reports of external expert panels on 176 higher education educational programs, implemented at 25 educational organizations.

To identify recommendations and comments from external expert panels, a Pareto analysis was conducted (Figure 2). 217 comments, shortcomings, recommendations of external expert panels (hereinafter - inconsistencies), were classified according to 7 ENQA Standards and Guidelines for Quality Assurance. It was found that the inconsistencies in Standard 1 “Policy (objectives, development strategy) and quality assurance procedures for educational programs”, Standard 2 “Approval, monitoring and periodic evaluation of educational programs”, Standard 3 “Assessment of students' knowledge / competencies”, Standard 4 “Quality assurance and competence of the teaching staff” account for 80% of comments, shortcomings, recommendations of external expert commissions.

This indicates that the main problems of Russian education are concentrated in the formation of goals and strategies for the development of educational programs [22, 25], the actualization of their content, the functioning of the quality assurance system, and the capacity building of students and teachers.

At the same time, the level of availability of educational and material resources, the level of development of the information system and public information systems are sufficient.

As a result of the analysis it was found that the most important generalized inconsistencies that limit the quality of education are the following:

Within the Standard 1 “Policies (objectives, development strategy) and quality assurance procedures of educational programs”:

- Insufficient involvement of students, teachers, employers and other stakeholders to the formation of goals, the strategy for the development of the educational program, to participation in the quality assurance policy implementation.
- Undeveloped system of students’ serveys to assess the quality and content of the learning process.
- Lack of clearly articulated methods for achieving and reviewing the goals of the educational program.

- Lack of a comprehensive quality assurance system.
- Lack of clear wording of the mission, goals and strategies for the development of the educational program.

Conclusion. The above analysis allows us to state the presence of the following problems of the effectiveness of the system of higher education in Russia:

1. ow level of business sophistication. The origins of this problem are concealed in the absence of established stable links between science and institutions (state, business), inadequate degree of joint scientific research. A striking example is Russia with one of the highest rates of students and graduates of natural science disciplines in the world, but clearly lagging behind in finding talented young people;
2. inadequate distribution of financing to attract highly qualified specialists from abroad. Despite all the financial investments and recruiting professionals, insufficient attention is paid to the issue of how to retain these professionals, creating favorable conditions for entrepreneurship. Moreover, no one deals with the effectiveness of the influence of foreign scientists on the local community. If this influence was positive, then how to maintain and increase the potential; in case of negative impact - what measures should be taken to minimize its strength, and most importantly how to prevent the repetition of mistakes in the future. All of the above implies a transparent and cyclical mechanism aimed at assessing the results of the activities of the specialists involved;
3. establishing the right course of innovation at the local level. The essence of the problem lies in finding a balance between the state's ambitious plans for creating advanced technologies and context-sensitive solutions to local problems. The solution often requires the problems of municipal energy, transport, sanitation; Innovations can be brought to regulate local handicrafts or the creative industries. And, perhaps, one of the most vivid examples of the realization of creative innovations, is the Netherlands. In fact, the country in terms of graduates of natural sciences specialties is at the level of Ghana, Ecuador, Cambodia and Brazil, which did not prevent them from taking the leading positions in the GII rating.

Here we are with another question: how can approaches in the innovation policies of developed countries be adapted to the realities of developing countries?

In order to answer this question, it is worthwhile first to look at the entire set of innovative policies existing in countries with a high level of GNI. The politicians of these countries recognize and use an innovative system approach to solving problems, where innovation is treated as a complex concept, and is the result of the interaction of all actors, politicians and institutions involved in the process of forming an innovative eco-environment. Over the years, it has come to realize that innovation does not bring quick returns, and investments in scientific development must be long-term, and often involve a high level of risks and losses. The policy, built solely on financial injections into the scientific sphere, will not bring the desired results: the innovation consists not only in the creation of the product, but in its implementation, promotion, and organizational adjustment.

So we can distinguish two main directions of establishing an innovation policy:

1. to improve the institutional conditions for innovation: business environment, availability of financial support, competitiveness, transparency of conducting commercial activities;
2. to improve models of collaboration of innovative actors with external partners. Models can be different: joint research, public-private partnership, clusters. More refinement of the model will be described in further studies.

It is recommended to build a policy on parities of "supply and demand". Such a policy implies the creation of a strong human capital and research base, which includes an innovative infrastructure, a high degree of development of markets and businesses that promote the development of innovative research results. Universities and research organizations are subsidized through foreign sources or through competitive funding mechanisms.

Another way to reform existing policies can be to focus on creating the so-called "innovation culture" [11]. This culture implies the interconnection of business, the student community and the public and is associated with the notion of entrepreneurial activity.

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