The approaches for assessing the quality of scientific research at St. Petersburg Mining university

Dmitry Radushinsky1*, Dinara Kremcheeva1, Ekaterina Smirnova1, and Alexandra Radushinskaya2

1St. Petersburg Mining University (SPMU, Mining University), Russia, 199106, St. Petersburg, 21line V. O., 2, Department of Metrology, Instrumentation and Quality Management
2St. Petersburg State University (SPSU), St. Petersburg, Russia 199034, Universitetskaya emb., 7–9, Department of Russian Policies

Abstract. The article considers approaches to the development of criteria for assessing the quality of scientific research in St. Petersburg Mining University, Russia (Mining University), the functioning of which contains the main features of research university as well as of a scientific organization. The research methods include expert assessments, analysis and synthesis and other desk research methods. Based on the analysis of the results of the scientific activity of the organization in recent years, a set of basic quantitative indicators has been developed, as well as a set of additional qualitative indicators of the effectiveness of the scientific departments of the university. Qualitative indicators, including the rating assessment of the research carried out by the Scientific and Technical Council of the university, are designed to complement the widely used scientometric data. Thus, scientometric, financial indicators and a comprehensive (multifactorial) qualitative assessment can serve as criteria for the quality assessment for the scientific activity of the university. The information obtained is relevant for the formation of a quality management system for scientific research at Mining University, as well as for other research universities with a similar organizational structure. However, the conclusions obtained cannot be automatically extended to the procedures for the formation of quality management systems for scientific research in organizations of a different profile. Keywords: research university, R&D, scientific activity, research quality, scientific unit, research quality indicators, quality management system.

Acknowledgements

The authors thank the Vice-Rector for Scientific Activity of St. Petersburg Mining University Ivanov M.V. for the support of the research and the head of the Department of Metrology, Instrumentation and Quality Management of St. Petersburg Mining University Gogolinsky K.V. for a useful discussion.

* Corresponding author: D.Radoushinsky@gmail.com
1 Introduction

Conducting one’s own research activities is a recognized tool for adapting to changes, maintaining stability and improving the efficiency of a large organization [1, 2, 3], including a university. At present, it is advisable to build the quality management system of the university in accordance with the trends in technology and economics, which are associated with the concept of "Industry 4.0" [4, 5, 6]. It should be noted that in recent years, the Russian government has been stimulating the development of scientific activities in scientific organizations and institutions of higher education, including "5-100" program, federal project "Science", “Priority 2030” program.

The purpose of this article is to develop approaches for assessing the quality of scientific research at St. Petersburg Mining University (Mining University) in order to further contribute to a quality management system (QMS).

The study is based on the analysis of: 1) Russian regulatory documents for educational institutions and scientific organizations (dated July 30, 2019 No. 544 and dated April 8, 2009 No. 312); 2) scientific publications on current trends in the activities of research universities, management and evaluation of the quality of scientific research; 3) features of the functioning system of scientific activity that were detected at the Mining University.

The work used methods of expert assessments, methods of analysis and synthesis and other desk research methods.

2 Publications review

A number of articles are devoted to assessing the quality of research in Russian universities. The paper [7] considers the criteria for evaluating the effectiveness of the scientific activities of the department as a department of the university using FMEA analysis (analysis of the types and consequences of failures) with the identification of inconsistencies using the example of the Kazan National Research Technological University. In the article [8], the development of key indicators for evaluating and criteria for the innovative development of the university was carried out in order to develop an integrated model for guaranteeing the quality of innovative activity using the example of universities in Kazakhstan.

The advantages, disadvantages and limitations of a number of currently common bibliometric indicators of scientific activity are considered in [9, 10, 11]. The authors of these publications concluded that quantitative methods for assessing the effectiveness of scientific activity are not sufficiently objective, and require application in combination with qualitative expert assessments. Proposals and experience of implementing quality management systems in the processes of scientific activity and in the educational processes of universities, as well as in various types of technological processes, are covered in a significant number of scientific papers. Thus, the improvement of university research management systems in Russian practice is considered in [12, 13, 14]. The article [15] proposes the creation of an innovation center at the regional level to improve the efficiency of the innovation management system within the framework of scientific and educational complexes of universities. It is assumed that the specified regional center would allow "to ensure the maximum consideration of innovative research and development and their dissemination throughout the system of higher education.

The created conditions for learning and the subsequent susceptibility of schoolchildren and university students as future researchers to new information are called strategic determinants for strategic scientific quality system [16] also, taking into account the current trends of Industry 4.0 and the knowledge economy, which pay special attention to personnel training [17, 18].

Since for China, as well as for Russia in recent years, it was important to enlarge the structure of educational and scientific institutions, the conclusions of the authors of [19, 20] are
of interest for managing the processes of interaction, division and merging of scientific
departments of the university.

Special attention is paid to the issues of trust in the results and the choice of research topics [21, 22, 23]. In a number of case-study works by Russian authors the aspects of improving the quality of training of mining engineers related to their interaction with industrial organizations through scientific research are also considered [24, 25, 26].

3 Results of the study

The formation of a quality management system (QMS) of any type of activity of an organization or its individual divisions is generally based on the understanding, comprehensive analysis and control of information coming from the “inputs” and “outputs” of the system, which is described in the system of generally accepted international standards for quality assurance, as well as in the standards dedicated to the Lean Production [27, 28, 29].

3.1 Roadmap for primary information analysis

To perform the work on the analysis of the actual parameters (inputs and outputs) and features of the Mining University scientific departments functioning, the following sequence of actions (“road map”, algorithm) was determined for obtaining and processing primary information for analysis.

1. Request to the Human Resources Department to obtain information on the current state and dynamics of changes in the composition of full-time employees of scientific departments (hereinafter referred to as the SD) in 2016-2022 by fields: position, age, gender, scientific degrees.

2. Analysis of the organizational structures of SD, including the composition of: laboratories, the apparatus of the SD and the apparatus of scientific areas of the SD.

3. Analysis of reports on scientific activities of the Mining University in the Ministry of Education and Science and thematic plans for contractual and state budget research work for recent years.

4. Obtaining information about the scientific results of the SD activities in recent years: articles, patents, computer programs, defenses and postgraduate training. At the request of the SD - the establishment of the "degree of activity" of graduate students attached to them based on the results of work.

5. Requests and processing of information on equipment of the SD: 1) ready for “use”, “sets”, faulty / incomplete equipment on the balance of SD; 2) equipment loading; 3) occupied space (is it possible to place additional equipment / remove faulty equipment); 4) the composition of the equipment additionally required for accreditation (in accordance with the methods claimed for accreditation), as well as for solving promising research problems of an engineering and fundamental nature.

6. Requests from the SD on the composition and substance of the contractual and state budget research works planned in nearest future (both engineering and fundamental) in the context of scientific areas.

3.2 Peculiarities of accreditation of scientific departments

The need to carry out work on the accreditation of laboratories related to various types of scientific centers in the national accreditation system (Rosakkreditatsiya) or in the international ILAC system (Analytics AAC and Rosakkreditatsiya) depends on the volume of engineering or fundamental work performed by a specific scientific unit and on the specific terms of current
and prospective contracts concluded by this SD, as well as grants received for experimental research from various sources.

It should also be noted that the confirmation of the competence of the laboratories of fundamental scientific centers is possible in Russia in the form of an assessment of the state of measurements (ASM). Compared to accreditation procedures, ASM is carried out in a shorter time and at lower prices by specialized organizations - state scientific metrological institutes and regional centers of metrology and standardization. This form of confirmation of the competence of laboratories is a feature of Russian legislation and is regulated by GOST R 8.892-2015 and MI 2427-2016. This form of confirmation of the competence of laboratories differs from the international standard 17025-2018. The consideration of the risks and opportunities of laboratory is not mandatory, but the tabular forms mandatory for use to reflect the data received in the organization are supplied. According to the authors, this form can be used to perform research work for the benefit of a limited number of customers in the domestic (Russian) market.

The decision to choose an accreditation scheme for testing and research laboratories belonging to various scientific departments of the university or confirmation of the competence of laboratories in the form of ASM depends on the needs of customers of the work performed by the scientific department at present and in the future (based on an assessment of the “capacities” of the laboratory).

### 3.3 Data characterizing the activities of the scientific departments of the Mining University

In the structure of funding sources for scientific activities of the Mining University, according to reports on research activities in 2018-2021, 78% - 90% were contracts with Russian legal entities, including the implementation of state tasks (Table 1).

Table 1. The share of funding sources for works and services of a scientific nature at Mining University in 2018-2021. Note: Table 1 was compiled by the authors.

<table>
<thead>
<tr>
<th>Sources of financing works and services of a scientific nature</th>
<th>Share in the total amount. %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2018</td>
</tr>
<tr>
<td>1. Contracts with Russian legal entities for the performance of all types of work</td>
<td>89%</td>
</tr>
<tr>
<td>2. Contracts and grants with foreign legal entities for the performance of all types of work</td>
<td>1%</td>
</tr>
<tr>
<td>3. Public sources. total</td>
<td>9%</td>
</tr>
<tr>
<td>including:</td>
<td></td>
</tr>
<tr>
<td>- a) subsidies, grants and targeted funding through the Ministry of Education and Science</td>
<td>7%</td>
</tr>
<tr>
<td>- b) federal state funds for the support of scientific activities</td>
<td>2%</td>
</tr>
<tr>
<td>- c) the regional budget of St. Petersburg</td>
<td>0.5%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

The share of targeted funding for the scientific activities of the organization through the Ministry of Education and Science in 2020-2021 increased significantly in absolute terms, in relative terms, the share of this source in the total amount increased from about 9% to 20% (line 3 of Table 1).
According to the reports on research activities in 2018-2020 and the forecast for 2021, the research conducted at the Mining University is mainly applied and exploratory in nature (Table 2).

**Table 2.** The share of scientific research at St. Petersburg State University in 2018-2021 by nature. Note: Table 2 was compiled by the authors.

<table>
<thead>
<tr>
<th>The nature of scientific research</th>
<th>2018</th>
<th>2019</th>
<th>2020</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fundamental</td>
<td>4.8%</td>
<td>4.8%</td>
<td>21.0%</td>
<td>19.3%</td>
</tr>
<tr>
<td>Applied</td>
<td>46.4%</td>
<td>46.5%</td>
<td>38.7%</td>
<td>38.5%</td>
</tr>
<tr>
<td>Pathfinding (searches)</td>
<td>48.1%</td>
<td>48.1%</td>
<td>39.9%</td>
<td>38.5%</td>
</tr>
<tr>
<td>Experimental</td>
<td>0.6%</td>
<td>0.6%</td>
<td>0.4%</td>
<td>0.0%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>100.0%</strong></td>
</tr>
<tr>
<td>Social Sciences</td>
<td>1.0%</td>
<td>1.0%</td>
<td>2.1%</td>
<td>1.9%</td>
</tr>
<tr>
<td>Natural and exact sciences</td>
<td>11.2%</td>
<td>11.2%</td>
<td>16.1%</td>
<td>16.1%</td>
</tr>
<tr>
<td>Technical and applied sciences. sectors of the economy. total</td>
<td>75.6%</td>
<td>75.6%</td>
<td>69.7%</td>
<td>64.2%</td>
</tr>
<tr>
<td>Including:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- mining engineering</td>
<td>42.9%</td>
<td>42.9%</td>
<td>38.6%</td>
<td>35.3%</td>
</tr>
<tr>
<td>- metallurgy</td>
<td>7.6%</td>
<td>7.6%</td>
<td>6.7%</td>
<td>6.4%</td>
</tr>
<tr>
<td>- chemical technology and industry</td>
<td>6.6%</td>
<td>6.6%</td>
<td>5.9%</td>
<td>5.8%</td>
</tr>
<tr>
<td>- others</td>
<td>18.4%</td>
<td>18.4%</td>
<td>18.5%</td>
<td>16.7%</td>
</tr>
<tr>
<td>General and complex problems (intersectoral problems)</td>
<td>12.3%</td>
<td>12.3%</td>
<td>12.1%</td>
<td>11.9%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>100.0%</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>

According to the table, from 2/3 to 3/4 of the ongoing technical scientific research in 2018-2021 were developments in technical and applied sciences (including mining, metallurgy and other areas) and in sectors of the economy (Fig. 1).

![Fig. 1. The proportion of scientific areas of researches carried out in 2020-2021 at the Mining University.](image-url)

The proportion of works and services of an engineering nature, performed by specialized scientific divisions (SD) of the university, during the study period ranged from 63 to 72% (Fig. 2).
Fig. 2. Share of works and services performed by the scientific divisions of the Mining University in 2017-2020.

The predominance of the engineering component in the composition of the performed scientific works and services means that the SD of the university successfully use the testing equipment that has a technological base for active work in the market with customers of applied, exploratory and experimental research. The connection of such processes with the success of technological transfer was noted before and, in the works, [30, 31, 32].

3.4. Assessment of problems, risks, prospects and opportunities for the development of scientific departments

For the purpose of an in-depth analysis of the activities of research centers and other types of SD’s of the university, the leaders of the SD were asked to fill out a questionnaire containing the following sections:

1. The main quantitative indicators of the results achieved in recent reporting periods and the planned results of activities in the context of scientific areas and the main topics of concluded contracts and grants for financing scientific activities: the amount of cash receipts; the nature, number and volume of scientific publications, registered patents and computer programs developed with the participation of SD employees.

2. The main problems and proposed ways of solving problems in the activities of the SD, including the problems of graduate students working in the SD (Table 3 as an example).

3. Vision of promising areas for improving the quality of SD work:

3.1. Improving internal procedures and procedures for interaction with other departments of the university with an answer to the questions: what elements of the existing procedures seem redundant, what elements are proposed to supplement the existing procedures?

3.2. Assessment of the prospects for expanding the activities of the scientific center due to:

- attracting new customers under business contracts;
- state and foreign grants for scientific research (the nature of scientific research in this case is mainly fundamental);

We also note that, according to the results of the survey, 68% of researchers are interested in simplifying the procedures for access to laboratory equipment for conducting initiative work.

Table 3. The main problems and the proposed ways of solving problems in the activities of the SD (example). Note: Table 3 was compiled by the authors.

<table>
<thead>
<tr>
<th>Key problems in the activities of the SD</th>
<th>Proposed ways to solve these problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of (serviceable) equipment to carry out the required range of scientific research. The estimated cost of the necessary equipment and repair work for the prospective period of 2022-2023 is $n rubles.</td>
<td>Accelerating the processing of SD applications for the purchase, repair (modernization) of research, testing, auxiliary equipment (furniture, office equipment), as well as consumables by the Procurement Department of the university. Improving the quality of</td>
</tr>
<tr>
<td>Key problems in the activities of the SD</td>
<td>Proposed ways to solve these problems</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Lack of required consumables to perform the required range of scientific research.</td>
<td>planning, implementation and rhythm of procurement financing</td>
</tr>
<tr>
<td>Regular change of priorities of fundamental scientific research, implementation of other tasks assigned to the SD</td>
<td>More consistent change of research priorities and tasks to be solved, timely informing about changes</td>
</tr>
<tr>
<td>A complex procedure for access to scientific and testing equipment for certain categories of users - graduate students (conducting research for their own scientific work), external users’ information to interested users</td>
<td>Simplification of procedures for access to scientific and testing equipment for graduate students and external users with the establishment of control procedures, measures and amounts of liability for possible damage with bringing information to interested users</td>
</tr>
</tbody>
</table>

### 4 Conclusions and Discussion

The results of the work carried out by the authors of the article in the Mining University:
- the analysis of the features of the scientific activity of the organization in the recent years;
- a questionnaire was developed to assess the main problems ("risks", "bottlenecks"), the proposed ways to solve them, as well as the possibilities for improving and expanding the activities of the scientific departments of the research university.
- a preliminary assessment of the effectiveness of the activities of the scientific departments of the research university was carried out according to the questionnaire.

The obtained research results can be used in the development of recommendations for improving scientific activities, for the formation of a quality management system for scientific research at the Mining University, as well as other research universities with a similar organizational structure. However, the conclusions obtained cannot be automatically extended to the procedures for the formation of quality management systems for scientific research in organizations of a different profile.

The main factors influencing the formation of the strategic profile of the activities of the scientific department of the university in the framework of building the QMS are:
- the ratio of works and services of an engineering and fundamental nature, determined by the management and the competences of researchers, on a short- and long-term basis;
- selection of qualified personnel and the ability to perform initiative, exploratory research by each of the employees (which, for example, is one of the principles for encouraging the innovative activity of employees in such leading companies in their fields as, for example, 3M, Apple, Yandex and others);
- the availability of necessary modern, metrologically reliable and serviceable equipment;
- the ability to initiate the conclusion and fulfill business contracts, works and services of an engineering and consulting nature.

The latter factor is one of the financial bases for conducting and promising fundamental research based on the testing and research equipment available to temporarily free or specially designated employees of this scientific unit.

Prospects for further research in the scientific direction of this article are as follows:
1. An in-depth analysis of the "best practices" of research and implementation activities of the world's leading research universities, including universities in the Asia-Pacific countries, Europe, the USA and Russia.
2. An in-depth analysis of quality management systems for scientific developments in the world's leading manufacturing companies.
3. Development of a methodology or individual algorithms for a comprehensive assessment of the quality of scientific research of scientific departments of a research university.
4. Development of documented procedures for quality management systems of scientific departments of a research university.

References

15. I.F. Feklistov, Ekonomika truda (Labor Economics) 7(12), 1235-1248 (2020)
20. Qiao, L., Mu, R., and Chen, K., Scientific effects of large research infrastructures in