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Features of the Information-analytical System Application for Estimation the Support Areas for Creation of the Results of the Intellectual Activity of the Research and Educational Institutions

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With the increase in governmental funding for science and the growing number of scientific studies, carried out under the support of the various funds, the problem of analysis and comprehensive assessment of the research results, as well as selection of the most promising research topics becomes quite acute issue. Therefore the problem of rapid and objective reflection of the science status, as well as evident estimations of research cost-effectiveness is highly relevant. These issues are the subject of scientific analysis throughout the world, and the creation of evidence-based practices and software to define the growing-points, geographical location and development trends is seen as the most important task in the science management. This article describes the research findings of the problem on assessing the status and development of the scientific investigations, using new techniques to analyze bibliographic and scientometric data in terms of the intellectual deliverables (ID), as well as to create integrated information system for the implementation of such methods.

Keywords: Information system, Criteria indicators, Quality management, Scientific personnel, Software package, System approach, Methodolog.

The information system is designed to manage and analyze the databases reflecting the results of intellectual activity (intellectual deliverables) of the staff of scientific or educational institution. Such a system provides data on the research areas under development, key accomplishments, research teams and individual researchers in terms of their geographical location, age, qualification and other criteria.

Currently, quality management is gradually becoming a complex system task that combines the best of the currently known methods of quality assurance and improvement into a single, unique, enterprise-wide system (Hirsch, 2005). Quality assurance is turning from the duties of a specialized service into a coherent philosophy, which is shared by all company units, the foundation of the corporate culture that is created by the management, determining all aspects of company activities (on the Federal ..., 2014).

The production quality management system is a combination of organizational structure, techniques, processes and resources needed for the general quality management of the organization (Christiansen, 2000). For high schools these are educational services, as well as intellectual deliverables, protected by documents of title of the Russian Federation or the copyright law.

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In accordance with ISO 9001:2000, certified organization should monitor, measure and analyze the manufactured products, as well as to take the necessary actions in order to achieve planned results and continual improvement of its performance, reflecting this in specialized databases of the Russian Ministry of Education (for example, (Database, 2014)).

The effectiveness of implementing such a system is indisputable, since it contains huge intrinsic and extrinsic advantages for the organization. Extrinsic advantages are associated to a large extent to the certification of the implemented system, making transparent the production process in the organization pertaining to a criterion, important for any company or government agency, such as products and services quality (Frey, 2007). In the works (Yastreb, 2012, Sugimoto, 2008, and Sinitsyn, 2014a) the use of such systems is considered for specific organizations.

Management of research and educational activities in higher education institutions is the most complex semi-structured management problem, which is characterized by:

a) A high degree of information uncertainty;
b) A large number of diverse input and output parameters, many of which are of qualitative nature, not formalized and therefore weakly quantifiable;
c) A complex, not clearly expressed performance criteria.

Complexity of the problem is due to the necessity of making a great number of decisions under the conditions of insufficient reliable information in an ever-changing situation. The decision maker faces with the need to collect and analyze vast amounts of information, therefore it is practically impossible to ensure high efficiency of decisions made without the regular use of information technology in all areas of the university activities (Sinitsyn, 2014a).

Today, many universities in Russia are solving the problem on monitoring and evaluating innovation-oriented activities of scientific and scientific-pedagogical staff. A variety of models have been developed that allow one to account the various performance indicators. However, foreign and domestic software market still lacks the universal comprehensive solutions that would allow one to describe various intellectual property attributes (from abstracts to utility model patents) in a single unified system (Sinitsyn, 2014b).

Thus we face with the problem, which can be characterized as a problem of rapid and reliable reflection of the university science status, as well as the formation of adequate criteria for assessing its effectiveness. This requires the evaluation of the effectiveness of funds allocated to R&D (research and development).

Scientific novelty of the current study is due to the lack of a comprehensive solution that would be applicable in a variety of educational and scientific organizations. One of the components of the quality management system is the development and application of methods to measure the effectiveness and efficiency of each process on the basis of the key quality indicators. Currently, research is being conducted on the development of such methods and indicators, though systematic results have not yet been obtained.

Most of today's corporate information systems of planning and management are very expansive and available only to large companies. In addition, they do not provide solution to the problem of the efficiency analysis in areas, characterized by poorly formalized categories, such as science, art, culture, etc. (Sinitsyn, 2014c).

The design of information system to control company staffing and the selection of criteria indicators to evaluate its performance efficiency would allow us to formalize and generalize the results of the employees activity in any organization, as well as to calculate aggregates in order to generate performance criteria on the basis of these data. Such systematic approach will allow processing the data for the calculation of general corporate and specialized criteria, including quantitative and qualitative, objective and subjective, integral and simple indicators.

Intellectual property, such as research papers, abstracts of a thesis, operation manuals, patents, theses, tutorials, computer software codes, databases, etc. may be used to assess the results of company or university performance. On the basis of the input data one can calculate a combination of various indicators, showing the effectiveness of the organization performance, as well as the analytical capabilities of the information system (Sinitsyn, 2014c).

System's structure

Currently, based on the Federal State Budget Educational Institution of Higher Professional Education "Vologda State University" (VoSU), works are underway to create a prototype system enabling to control the university staff composition and design criteria performance indicators to evaluate the university activities.

Generalized structural model of the system (Fig. 1) includes four main consolidated blocks: 1 - performance management block, 2 - indicators formation and calculation block, 3 - staff space management block, 4 - patents management block; and three logical databanks: 5 - performance database, 6 - standard reference database, 7 - staff database, and 8 - patents database.

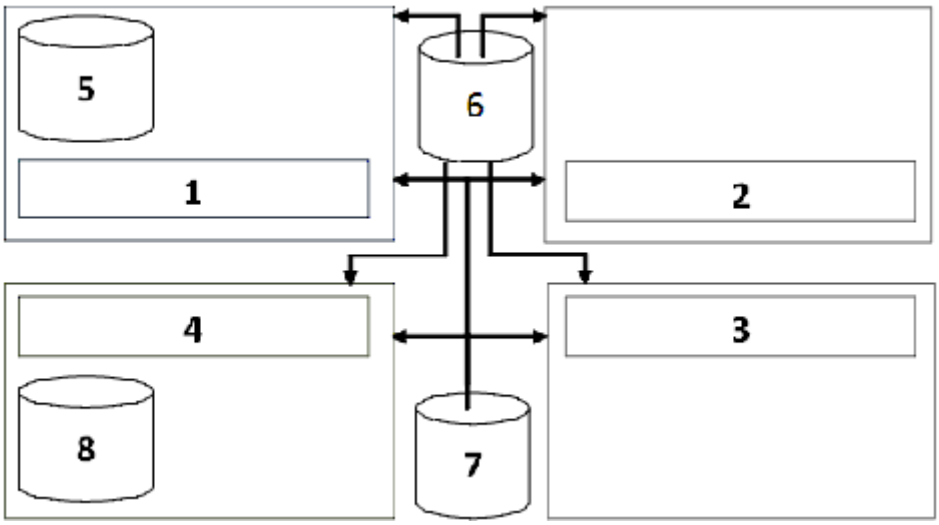


Fig. 1. Generalized structural model

Staff space management block is a central element of the system and is responsible for the management of primary data. The structure of the block can be divided into two main subsystems: standard reference data management subsystem and staff data management subsystem. Standard reference data management subsystem is responsible for managing directories of various attributes and object properties. For intellectual property these include positions, business units, types of employees, scientific degrees, academic qualifications, research and education centers, research areas, scientific schools, journals/ collected works, publishers, etc. Staff data management subsystem includes information on all employees in the organization with the emphasis on final product of their activity (i.e., intellectual property). The subsystem is implemented via the general reference-list, as well as through employees' individual cards. Subsystem of directories coordination enables the use of standard reference data when working with employees attributes.

System capabilities

Indicators formation and calculation block is the analytical core of the information system for monitoring, forecasting, and stimulating innovation-oriented activities of academic staff and scientific-pedagogical personnel of the university. Its main task is preparing the data for further calculation of various performance criteria. The system implements the following set of functions to build reports.

Search for intellectual property in the context of employees-authors and objects-results

This method makes it possible to find a great number of intellectual property items that meet the search criteria. All parameters, which define the search, are divided into two groups (they are implemented using visual tabs). The first group consists of properties that describe the objects-results, which include the type of the object, the journal/collection, publisher, city, country, year, etc. The second group includes properties related to the authors, such as department, position, scientific degree, academic qualification, research area,

scientific school, research and educational center, date of birth, etc. The above approach allows us to analyze the innovative and publishing activity of both individual employee, and the entire university as a whole in the context of various statistical views.

Search for authors of intellectual property in the context of employees- authors and objects-results.

This function allows us to compose a list of authors that satisfy the filtering conditions. Search is also carried out with the help of attributes that apply to the intellectual property items and the employees-authors. This type of search allows us to analyze the structure of the authors array, involved in innovative and publishing activities, in terms of various statistical views.

To specify complex filtering conditions we use the items cross-searching mechanism by employees with inheritance of the parent query search terms. For example, first we build a list of employees-authors under a certain conditions, and then, based on certain attributes, we filter out the intellectual property items from the obtained goal set of all items, created by these authors. To format the generated reports, one can use both standard and custom templates, which are described by a special tag-based macro language.

Arbitrary statistical reports with adjustable horizontal and vertical structure.

This type of reporting is designed to calculate the aggregates in various statistical views depending on object type. Employees, departments, areas, education and research centers, scientific schools, etc. can be used as object-lines, whereas the object-columns are selected from types of intellectual property. A comprehensive specification is implemented for each cell of the report as an optional feature. In addition, the columns and lines can be provided with an intermediate and final summation.

Statistical data analysis

For the period from 2000 to 2014 the database on intellectual deliverables (ID) of the Vologda State University accumulated information about more than eight thousand intellectual property items. For convenience, all ID are grouped into the following categories:

a. research;
b. courseware;
c. protective;
d. information and publicistic.

Research category of ID includes the following:

a. abstracts of a thesis for acquiring a scientific degree;
b. monographs and multi-author books;
c. deposited articles;
d. registered R&D reports;
e. papers in the proceedings of scientific events;
f. articles in the journals included into the Scopus and Web of Science international citation databases;
g. articles in journals recommended by the State Commission for Academic Degrees and Titles of the Russian Federation (VAK);
h. articles in publications of scientific conferences;
i. articles in foreign editions;
j. articles in Russian periodicals;
k. abstracts in proceedings of scientific conferences.

Courseware category of ID includes the following:

a. courseware assignments;
b. lecture materials;
c. laboratory course;
d. laboratory operations manual;
e. educational, teaching and training manuals;
f. curriculums;
g. case-studies and tests.

Protection category of ID includes the following:

a. copyright certificates;
b. information cards;
c. invention patents;
d. utility model patents;
e. “know-how” registration certificates;
f. certificates on registration of computer software and databases.

Information and publicistic category of ID includes the following:

a. broshure;
b. book;
c. manuscript;
d. proceedings;
e. regulatory collection;
f. reference edition;
g. electronic resource.

Figure 2 shows the percentage of the ID with respect to the specified categories. It is obvious that research works make up 67% of the total ID.

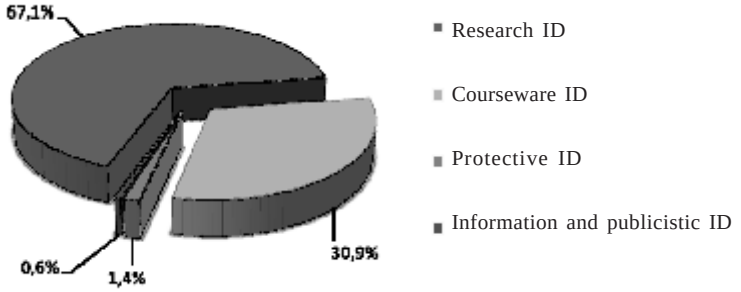
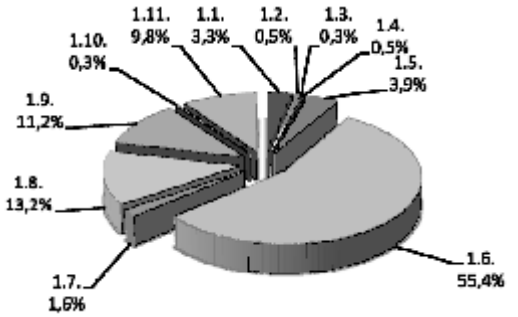
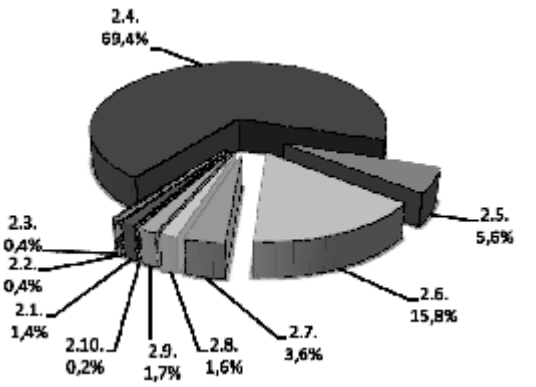


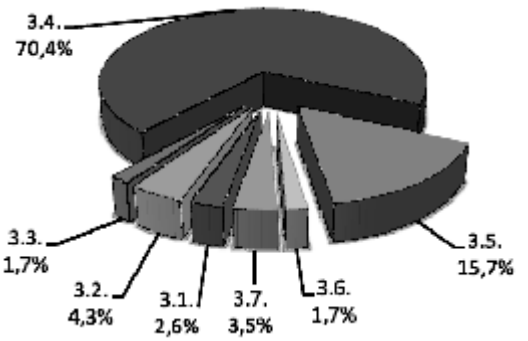
Fig.2. The ID distribution diagram.



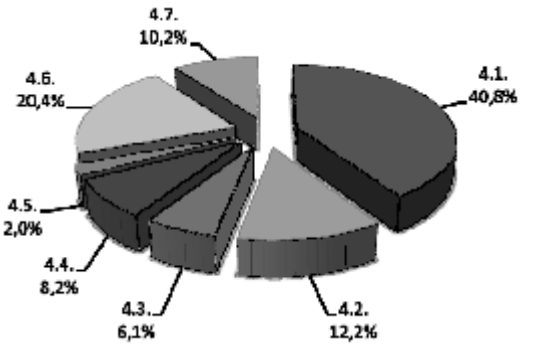
A) Research



B) Courseware



C) Protective



D) Information and publicistic

1.1. monographs; 1.2. abstracts of a thesis; 1.3. reports; 1.4. progress reports; 1.5. WoS & Scopus registered articles; 1.6. articles in the proceedings of scientific conferences; 1.7. articles in the foreign editions; 1.8. articles in the periodicals; 1.9. articles in the VAK-reviewed journals; 1.10. deposited articles; 1.11. abstracts;
2.1. assignments; 2.2. lectures; 2.3. laboratory courses; 2.4. laboratory operations manuals; 2.5. manuals; 2.6. tutorials; 2.7. courseware; 2.8. work programs; 2.9. case studies; 2.10. tests;
3.1. copyright certificates; 3.2. information cards; 3.3. computer software; 3.4. invention patents; 3.5. utility model patents; 3.6. “know-how” registration certificates; 3.7. certificates of computer code and database registration.
4.1. brochures; 4.2. books; 4.3. manuscripts; 4.5. collections of papers; 4.6. regulatory collections; 4.7. reference editions; 4.8. electronic resources.

Fig. 3. The ID distribution diagrams by categories

The diagrams in Fig. 3 show the percentage of ID according to the categories described above. Analyzing the ID distribution by the categories and subcategories, we can make the following conclusions:

1. In terms of a number of items included into a common ID database, the leading position is occupied by a research category. At that, more than half of included items are the articles published in the proceedings of the university scientific conferences (including those held in VoSU), whereas 13% are the publications in Russian periodicals (see Fig. 3A).
2. Courseware ID are represented mainly by operation manuals (up to 70%) and tutorials (16%) as the most common types of publications in higher education institutions (see Fig.3C).
3. The greatest scientific and technological potential have invention patents (70%) and utility model patents (up to 16%, see Fig.3C).
4. In the category of information and publicistic ID, brochures show over 40%, while reference editions make up 20% (see Fig. 3D).

CONCLUSIONS

Implementation of the above-described information system will allow one not only to store and process data about the focus areas of research and educational institutions, their performance results, the quantitative and qualitative aspects of staff, but also to build a variety of performance indicators both for an individual average executive, and the organization as a whole.

Implementation of that kind of system will enable education and research institutions to create favorable conditions for the implementation of a unique opportunity to establish or improve the quality management in order to form the hard-working team and achieve competitive advantages within their services and products market. This system will make it possible to formalize and generalize the results of scientific and pedagogical personnel activity, to calculate aggregates and generate performance measures based on obtained data. The program and its implementation technique will provide conditions for data processing to calculate various criteria, including corporate and specialized, quantitative and qualitative, objective and subjective, integral and simple ones that will contribute to the formation and sustainable implementation of quality management system.

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