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INFORMATION TECHNOLOGIES FOR MEASURING THE QUALITATIVE AND QUANTITATIVE INDICATORS OF HIGHER EDUCATION INSTITUTIONS WORK

Abstract. Today, the old methods of management are transformed into qualitatively new achievements of management science. So, the question of the effectiveness of management of educational institutions is still open. One of the important areas of management reform is the use of the latest management technologies, such as information systems that are successfully integrated with proven management methods. The source of information for determining qualitative and quantitative indicators of the work of higher education institutions (HEI) should include special systems and services, which will provide the processing of indicators of scientific, educational, economic activities, etc. Indicators and criteria for their evaluation should be clearly defined and approved, and, accordingly, special algorithms and approaches to their calculation and analysis should be developed. Accordingly, the aim of the article is to suggest algorithms and tools for measuring quantitative and qualitative indicators of the work of HEI, and their implementation on the example of Kherson State University. In particular, the method of rating evaluation of research and teaching staff was considered in the paper. The main tools and technologies for automating the monitoring of research and educational personnel (REP) activities, as well as examples of their use, were described. The main feature of the described approach is the ability to ensure the automation and transparency of the main business processes of the HEI. Developed software, information, and analytical systems allow for assessing the qualitative and quantitative indicators of the HEI's work, taking into account its visibility in the domestic and international scientific and educational space,

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which includes the results of scientific activities (indicators for WoS, Scopus, etc.), educational activities indicators of graduates 'success, management of students' research works, student surveys, etc.).

Keywords: higher education institution; university management; quantitative indicators; qualitative indicators; scientometric indicators; rating systems; information technologies.

1. INTRODUCTION

Statement of the problem. Today's realities demand openness, flexibility and responsibility to changes in the educational environment. Analyzing the most relevant world universities rankings, we realize that the main criteria for assessing the activities of HEI today are:

- Reputation in the academic environment, citations of scientific publications of university representatives, the ratio of teachers and students, the attitude of employers to graduates, the relative number of foreign teachers and students - ***QS World University Rankings*** [1].
- Quantitative indicators of Nobel Prize Laureates or Fields Medal winners among university graduates and staff; the number of "frequently cited researchers in 21 categories"; the number of articles published in the journals Nature or Science; citation indexes for natural sciences and humanities of the Institute for Scientific Information (ISI) Science Citation Index and Social Sciences Citation Index, as well as indices of leading journals Arts and Humanities Citation Index, student performance - ***Academic ranking of world universities*** [2]
- Quantitative and qualitative indicators in such categories as: teaching (educational sphere); research (number, income and reputation); citations (research impact); International perspectives (staff, students and research); and industry income (knowledge transfer) - ***Times Higher Education World University Rankings*** [3].

Ensuring the quality of each of the defined criteria requires addressing the effectiveness of university management, which primarily indicates the relevance of organizing and conducting research on ways of effectively building a model of learning environment and its implementation in the educational process, and accordingly - identify key problems, tools and management technologies.

To implement innovations, educational institutions need to connect to the process of implementing informational technologies (IT) in educational and administrative processes, to create innovation and technology centers and technology transfer centers in universities. It is important to pay attention not only to the current state of information and communication technologies of the university, but also to the strategy of their development.

According to our research, held in 2011, of the state of Information and communication technology (ICT) infrastructure development in Ukrainian universities, we assume that only those educational institutions, whose IT structure has a high degree of development, have a high rating. Thus, for each of the 105 studied universities the correspondence of the real state of information technologies of educational institutions to their world and state rating was established. Given that, we claim that improving the level of organizational and resource provision of educational and administrative processes of HEI today is a natural process. Though, unfortunately, it does not guarantee the growth of quality of educational services, because the availability of the necessary resources and the efficiency of their use are different issues, which depend on various factors. That is why the question "How to manage IT resources?" is more actual today as the question "Where to find?", which indicates the need for a higher level of information competence and an effective IT management system.

As an example, it is enough to give the following data: Sumy State University - 501-600th in the Times Higher Education World University Rankings 2022 and 5th in Academic rating of HEI of Ukraine "Top-200 Ukraine 2021", Lviv Polytechnic National Univesity - 601st and 4th places respectively; Kharkiv National University of Radio Electronics - 1001-1200th and 12th; National Technical University "Kharkiv Polytechnic Institute" - 1201th and 7th places.

Each of these universities has a clear development strategy, a well-developed IT infrastructure as well as it plays an important role in implementing IT processes to the educational and scientific space of the country. Therefore, it can be concluded that the correct construction of the IT infrastructure of the HEI affects not only the improvement of quantitative and qualitative indicators of administrative and educational processes, but also the increase of tuition fee. It only remains to determine the priority areas of development and ways to achieve the tasks.

An important stage of this process is the monitoring of the development and implementation of information technology in educational and business processes of HEIs, the study of changes in the ranking of the university and their dependence on realization certain strategies of information technology development of higher education institutions.

Given that, the article focuses on determining the main types of business processes of the university, analysis of algorithms and means of measuring quantitative and qualitative indicators of the work of HEI, and also their implementation on the example of KSU.

Analysis of recent research and publications. Problems of ICT in education are the main research area of the International Research Center of Information Technologies and Systems of the National Academy of Sciences of Ukraine and the Ministry of Education and Science of Ukraine, which is part of the Cybernetics Center of the National Academy of Sciences of Ukraine. Many research teams were established and are actively working on problems related to the realization of ICT in education at the Ukrainian universities.

In his article [4] Bykov V. states that “the effectiveness of informatization of the education system definitely depends on how ICT systems are built. ICT systems provide information and procedural support for all activities of educational organizational structures (EOS), and constitute the computer-technological basis of the environment of EOS. In particular they provide procedural support for the learning environment and give the answers to the main questions: how it is built; what functions it performs; according to what rules the ICT subdivision of the EOS works; its employees who make up the personnel core of the automated ICT system; how the automated functions of these systems are shared between the ICT unit and other EOS units”.

Speaking about the management of business processes of the university, we consider that most numbers of scientific publications are devoted to the means and technologies of automation of educational and management processes of universities and other educational institutions. For example, in the article [5], on the example of Vinnytsia National Technical University, the approach to complex automated data processing and document flow of HEI is described, taking into account the requirements of the Bologna process. The models and algorithmic support of the system of document circulation, monitoring and management of the educational process of master 's preparation, means of information support of decision - making developed by the authors are presented. The article [6] discusses the problems of choosing a technology platform and creating a universal management system for educational resources, in particular, indicates the effectiveness of cloud technology and Google Apps. The article [7] is devoted to an overview of the functionality of the existing software for managing the educational process of HEI. In particular, the functional capabilities and use of the information-analytical system "Dean's Office" (developed by specialists of the private company "Politek-SOFT") are described on the example of Zhytomyr Ivan Franko State University.

In [8] the characteristics of "innovative universities" were considered - particularly such universities' willingness to adapt to changing environments and how they seek to do so. The challenges facing universities were identified. The question why universities need to adapt their research, teaching and learning, and knowledge transfer is considered. In [9] the processes of HEI readiness to apply methodologies for managing digitization projects were investigated and the methodological concept of project management of transformation of Ukrainian higher education institutions into digital universities was proposed. Examples of digitization projects of the National Aviation University were given. The article [10] considers the mobile communication subsystem that was developed by the authors for teachers and students, which interacts with the electronic management system of the university. In [11] the approach to retrieve and transport new attributes through the eIDAS (electronic IDentification, Authentication, and trust Services) infrastructure in a selected set of academic services was described. The design, implementation, and installation of two eIDAS-enabled academic services: the eRegistration in the Erasmus student exchange program and the Login facility with national eIDs on the university portal were presented. In this article [12], ICT infrastructure and the extent of its usage in Nigeria universities were investigated. The main ICT infrastructure and services utilized in Nigeria universities were identified to include the computer, the internet, E-mail services, the World Wide Web, website, and telephone. The authors say that ICT infrastructure is lacking in Nigeria universities and the utilization is low. In [13] a set of recommendations for the use of digital repositories for the modern strategic planning for the smart infrastructure of universities on the example of the University of Palestine are presented. The article [14] is devoted to the investigation of the impact of information technology (IT) Infrastructure on Innovation performance as a critical issue in the Iraqi private Universities.

Given that, we claim that the interest of scientists to define the essence and improve business processes is increasing today. Though, a complex approach to the effective management of business processes of universities in the scientific literature is almost absent. Accordingly, the problem of research of business process management of the university today is still open-ended.

Despite the importance of resolving this problem, there are objective preconditions for the universities of our country that make it difficult to achieve the desired results. These include: lack of adequate funding, unsatisfactory means of telecommunications, outdated approach to the organization of the educational process, lack of interaction between universities and IT companies, the outflow of the best qualified personnel abroad, etc. Accordingly, the introduction of ICT in the management of higher education institutions and the definition of a clear information and communication structure of higher education institutions can be considered an impetus for solving this problem in Ukrainian universities.

This paper refers to further researches on joint international projects, such as Tempus TACIS CP No 20069-1998 "Information infrastructure of higher education institutions", Tempus TACIS MR JEP 23010-2002 Information technology in the university management network. UniT-Net », Tempus JEP-27247-2006« CLIP Services for training and individual development of students », Tempus JEP-27237-2006« CC4U2 curriculum in computer science for Ukrainian universities », etc.

The main results of research on this problem are reflected in the works of the authors. In particular, in [15] author's vision on ICT development of Dissertation Committees and Graduate Schools (DC & GS) infrastructure was proposed. The performance of DC and GS through their web indicators was analyzed. The article [16] deals with solutions of some problems connected to development of feedback services while surveying students in an educational environment at a higher education institution. Introduction of the service "KSU Feedback" at Kherson State University on the basis of the Department of Informatics, Software Engineering and Economic Cybernetics had a positive impact on creation an educational environment where higher

education institutions become a corporation for serving the students. Articles [17-19] describe authors' experience in developing rating system for universities based on scientist's scientometric indices. The philosophy of the system is providing open data of different scientometric systems.

The research goal. The aim of the article is to suggest algorithms and tools for measuring quantitative and qualitative indicators of the work of HEI, and their implementation on the example of Kherson State University**.**

2. THE RESULTS AND DISCUSSION

University business processes. Types. Measurement. Analysis. The model of university management as a set of interconnected business processes includes methods for measuring qualitative and quantitative indicators of processes, description of the content of monitoring by the indicators of processes, analysis of problems and inconsistencies, measures to adjust and improve business processes. Thus, we ensure the fulfillment of the necessary conditions for the development of an effective and efficient management system, namely - ensuring transparency and clarity of the created informative environment for management decisions, as the basic principles of the theory of process approach.

It should be mentioned that if in a normal business process the collection of information is carried out from customers who directly use the products, the uniqueness of the university is that it, unlike commercial structures, does not "produce" material products, but "produces" human capital. Consequently, all needed information is obtained from the "product" - students, graduates, employees.

The introduction of process management at the university involves:

- firstly, the existence of regulation of business process that describes the process itself, management factors that influence on it, mechanisms and resources for the implementation of the process, and, also, its results;
- secondly, identification of business process owners - persons responsible for the implementation of a particular business process;
- thirdly, the separation of basic categories to ensure optimal detailing of the description of business processes of the university;
- fourthly, the classification of business processes.

Process management shifts the emphasis from the management of individual structural elements to the management of end-to-end business processes, which together link the activities of individual structural elements, permeate the organizational and staffing structure horizontally.

The structure of business processes at the university consists of the following groups:

- management (coordination) of educational services (teaching activities);
- management (coordination) of scientific and innovative activity;
- management (coordination) of international activities;
- management (coordination) of educational and socio-humanitarian activities;
- personnel management (coordination);
- management (coordination) of economic and financial development of the university;
- management (coordination) of information and communication infrastructure;
- management (coordination) of economic activity and logistical support.

Such approach to the architecture of business process enables (subject to effective management) constant improvement of the university work efficiency at all levels.

The described business processes in their structure have hierarchically subordinated and internally interconnected subprocesses. Since the main task of the university is the "production" of human capital, as the main groups of business processes at the university, we highlight:

1. **Management (coordination) of the provision of educational services (teaching activities), which in turn involves a number of sub-processes:**
   - formation of curricula;
   - calculation of teaching load of research and educational personnel;
   - drawing up a schedule of classes;
   - development of educational materials;
   - collection of the information about university students success and achievements;
   - providing feedback between student and teacher;
   - ensuring compliance with the principles of academic integrity.

2. Management (coordination) of scientific and innovative activities, which includes subprocesses:
   - publishing activity of research and educational personnel;
   - implementation of research projects that meet sectoral priorities, as well as international grants received for the implementation of research projects;
   - coordination of publication activity of the scientific journals of the university;
   - coordination of the activities of Dissertation Committees;
   - functioning of scientific schools and scientific laboratories;
   - professional development (advanced training) of research and educational personnel;
   - functioning of student scientific associations (problem groups and scientific circles).

3. Management (coordination) of international activities, which involves subprocesses:
   - implementation of international mobility projects in the field of higher education;
   - implementation of the project of "double diplomas";
   - implementation of international grant programs received for the implementation of scientific (educational, cultural, artistic, social, etc.) projects.

Having analyzed the selected business processes and comparing them with the criteria by which universities are evaluated by international rating organizations, we revealed full compliance of quantitative and qualitative indicators that can determine the effectiveness of these business processes. Accordingly, one of the main tasks is to determine the algorithms and tools for collecting business information and measuring indicators of "core" business processes.

Information collection, as a continuous process of functioning of the university, can consist of two main parts: continuous collection followed by systematization of general business information from informal sources, and, also, constant updating of information from official sources [20], provided by the introduction and maintenance of a clear information and communication structure of HEI.

Having analyzed the selected subprocesses of the "main" business processes of the university, we concluded that the key indicators of evaluating their effectiveness is to assess the results of educational and scientific activities of key subjects(participants) of the educational process - students and teachers.

The evaluation of the results of educational and scientific activities, in turn, can be based on such rates: the number of scientific publications in periodicals (scientometric databases Scopus or Web of Science Core Collection inclusive), the scientist's h-index (according to scientometric systems and databases), citation of the scientist (according to scientometric systems and databases), number of monographs, textbooks, tutorials, research projects, preparation of students for competitions and supervision of student research works, membership in DS, etc.

It should be mentioned that these indicators directly determine the effectiveness of the structural units of the university and the university as a whole. In the present educational society these indicators are applied:

- in international rankings and databases;
- during accreditation, licensing of educational programs, specialties;
- in the ratings of relevant state bodies, Ukrainian agencies, mass media;
- in the annual reports of the university (by areas) that are submitted to the Ministry of Education and Science of Ukraine.

Given that, the indicators and criteria for their evaluation should be clearly defined and approved, and accordingly, special formulas for calculating the rating of the activities of research and teaching staff, teaching and support staff and students should be developed. For example, in Kherson State University, a methodology of rating assessment [21] and monitoring of the activities of a research and educational personnel (REP) was developed.

According to this method, the evaluation system of research and educational personnel as well as departments and faculties of the university is carried out. Indicators of rating assessment are divided into groups (research, international activities, educational activities, social and humanitarian activities). For each indicator, the measurement indicators, the number of points and the corresponding weights are determined [21].

Let consider in more detail the formulas for calculating ratings:

– **formula for calculating the personal rating of the research and educational personnel (REP) (regardless of the share of the rate of the staff) for three years:**

$$R_{REP} = \sum_{i=1}^{20} \Pi_i$$

where R_{REP} - REP rating for three years;
Π_i - rating indicator;
i - the number of the rating indicator from 1 to 20.

– **formula for calculating the rating of the department (for three years):**

$$\boldsymbol{R_D} = \sum_{\boldsymbol{j=1.1}}^{\boldsymbol{1.10}} \Pi_{\boldsymbol{j}} + \frac{\sum_{\boldsymbol{i=2.1}}^{\boldsymbol{2.10}} \Pi_i}{REP}$$

where $\boldsymbol{R_D}$ - department rating for three years;
Π_i, $\Pi_{\boldsymbol{j}}$ - rating indicators;
$\boldsymbol{i, j}$ – numbers of the rating indicators;
$\boldsymbol{REP}$ – the number of research and educational personnel of the department.

– **formula for calculating the rating of the faculty (Annex 3):**

$$\boldsymbol{R_F} = \sum_{\boldsymbol{j=1.1}}^{\boldsymbol{1.10}} \Pi_{\boldsymbol{j}} + \frac{\sum_{\boldsymbol{i=2.1}}^{\boldsymbol{2.10}} \Pi_i}{REP}$$

where R_F - faculty rating for three years;
Π_i, $\Pi_{\boldsymbol{j}}$ - rating indicators;
i, j – numbers of the rating indicators;

REP – the number of research and educational personnel that are working at the faculty.

The rating of full-time REPs is determined by a permanent rating commission, the members of which are approved by the rector. The chairman of the rating commission, as a rule, is the rector of the university, the deputy is the first vice-rector. The rating commission includes vice-rectors, representatives of the educational department, educational and methodical department, education quality assurance department, personnel department, deans of the faculties, a representative of the student government.

The results of the rating assessment are public. The results of the rating assessment for the top 10% of REP are published on the university website by categories of participants.

The results of the rating assessment are used when making decisions on:

- moral and material encouragement of REP, departments, faculties;
- reasonable distribution of rates at the departments;
- competitive selection to fill vacant positions of REP, etc.

What is important, is that the indicators and evaluation criteria are objective, reliable and measurable. Any information provided in the appendix to the evaluation letter is carefully checked by the relevant departments and services of the university.

Implementation of the methodology of rating evaluation of REP performance indicators in such groups as research, international activities, educational activities, social and humanitarian activities, allows to qualitatively assess the indicators of "basic" business processes of the university, identify problems and ways of development.

Accordingly, the automation of business processes, as well as the automation of collection and processing of business information remain an open problem. Examples of relevant tools and technologies are discussed in the next section of the article.

HEI IT infrastructure. Automation of business process. The development of information and communication technologies of administrative direction, information and communication pedagogical environment simultaneously depends on the information resources of the university and IT infrastructure.

WEB-Portals of the university serve as the information resources of the HEI. They should contain complete and detailed information about the structure of the university and its work. The portals provide data about institutes, faculties, departments, and divisions of the university, its employees, leading teachers, and their scientific schools; information about projects, forms of education, specialties, the order of receipt and methods of payment; the latest news related to the life of the university: conferences and seminars, educational and entertainment events, the publication of scientific and methodological journals, the work of laboratories and centers, as well as events in the field of science and culture.

Legal resources are the regulatory framework of the university, which is aimed at the development of IT and the introduction of information technology in the educational process. As for technical resources, their components and basic characteristics must face the modern requirements of higher education.

Speaking of automation of the business process, we are not mean document management only. We include in this concept the various operations that are performed by participants in business processes, automatic processing of business information, the ability to interact with external IT systems. Given that, all of the "basic" business processes of the university require automation, and, also, other processes that require a lot of time for processing and analysis of information and for other routine work.

Consider the example of automation of "basic" business processes in the example of Kherson State University (Fig. 1).

Fig.1. Tools for "basic" business processes of the university automation

Information and analytical system (IAS) - a business application that allows you to keep records and students, accounting, control over tangible assets [22].

ST-Entrant - is designed to automate the accounting and control of entrants to educational institutions. The possibility of entering and further operative access to the information about the entrant, as well as to the list of faculties, specialties, and documents required for admission is realized. It is possible to search for a specific entrant and sort by selected criteria [22].

"KSU Feedback" service - is designed to conduct anonymous or regular voting according to clearly defined criteria among a strictly defined set of respondents. The service provides a wide range of tools for organizing data storage; analysis of results; distribution of access levels by voting organizers; effective teamwork [22, 23]. It is used to provide feedback to students and teachers, evaluate the activities of the REP, feedback with participants of conferences that are held on the basis of KSU, etc.

System "tutor-net" - an analytical information system for storing, displaying, and analytical processing of information about the activities of research and teaching staff and students of the university. It also provides automation of the process of preparing various reports on educational and scientific activities, etc. The system is currently in the final stages of development [22].

System "Publication" - provides automatic collection and analysis of scientometric indicators of REP according to Scopus, GoogleScholar, Publons, SemanticScholar, construction of REP ratings and structural units of the university, search for publications in various scientific fields, etc [17-19, 22].

eLibrary is a program of KSU library development aimed at improving information and library services, changing priorities in the field of information activities, introducing new forms and methods of acquisition of library funds [22].

The *WEB-Portal* of Kherson State University (www.kspu.edu) contains complete and detailed information concerning the structure of the university and its work. The portal contains the latest news related to conferences and seminars, educational and entertainment events, the publication of scientific and methodological journals, the work of laboratories and centers, as well as events in the field of science, education, and culture [22].

A fragment of the e-environment formed by the resources that are described above with a reflection of their interaction is presented below (Fig.2).

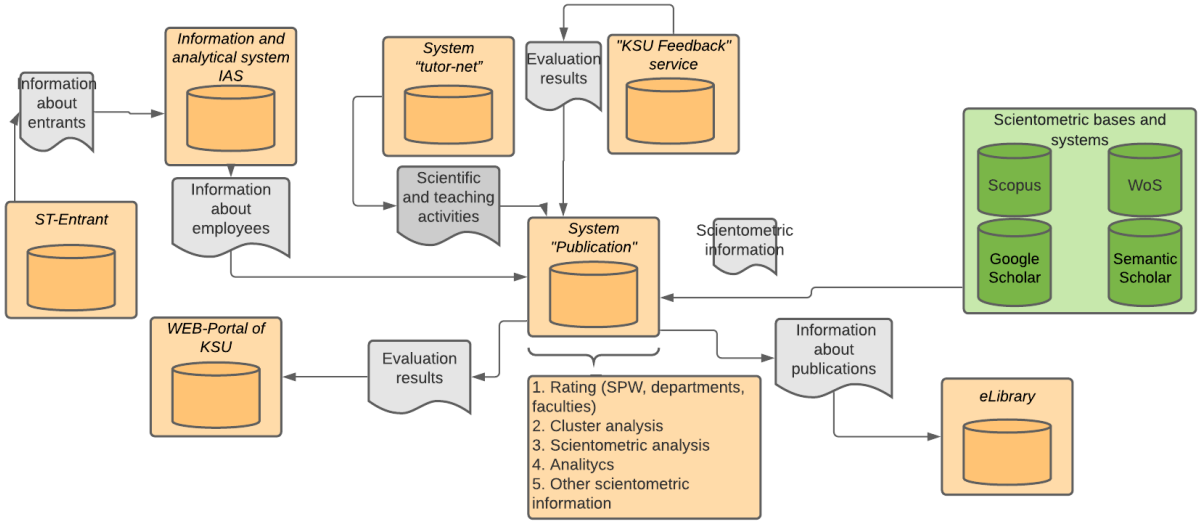

Fig.2. A fragment of the e-environment of HEI business process management

As it is presented in Figure 2, the service "Publication" is the "central" system associated with all other resources. As it was mentioned above, this service is responsible for collecting, processing, and presenting quantitative and qualitative indicators of the work of the REP. With the help of the parsers that we have developed, scientometric information (h-index, count documents, citation, etc.) from Scopus, Google Scholar, WoS, Semantic Scholar is updated once a quarter (3 months). The collected information is stored in the Publication service. In parallel with the updating of scientometric indicators, the assessment of REP is carried out by students. Students evaluate teachers according to such criteria:

- the teacher presents the material in an accessible and clear way and explains the main points (or difficult questions);
- clearly formulates tasks for unsupervised work;
- focuses on the use of the studied material in future professions and social activities;

- interests and maintains an interest in his course (motivation);
- teacher' demanding;
- objectivity in assessing students' knowledge, skills, and abilities;
- speech behavior: communication, diction, the pace of teaching;
- punctuality, etc.

The assessment results are converted into numerical values, after which they are also transferred to the Publication system through the API.

We use the “tutor-net” system as a tool for displaying not only the results of scientific, but also the pedagogical activity of REP. In addition, the system contains information about the seminars held by the REP, scientific publications that are not indexed by scientometric systems that are mentioned above. The system is also used as a service for the automated generation of scientific reports of faculties and departments. Publication and tutor-net systems interact via API.

The IAC system displays additional corporate information that is necessary for the formation of ratings. Thus, the information obtained from various sources is accumulated in the Publication, after which the results of scientific and teaching work of the REP are analyzed. Thus, we obtain and analyze a number of criteria necessary for the assessment. The rating results are displayed in Publication (in more detail) and partially on the KSU WEB-Portal.

One should know, that the automation of business processes of the university requires the introduction and use not only of internal (developed by the university) resources that are described above, but also requires the involvement of additional tools, services, and systems. In particular, their use is possible to improve and supplement the functionality of existing software and systems. Thus, the automation of information processing (construction of analytical reports, cluster analysis, etc.), for example, the obtained indicators of monitoring the activities of research and teaching staff, is possible through the use of special software and resources:

1) Power BI - analytical environment (a complex of programs and online services), which provides the ability to connect easily to any download of information from different sources, combine and bring this information into a single standardized model, calculate the necessary parameters based on this combined data, construction of visual graphs and reports [24]. Accordingly, the service allows to visualize the received data, create intelligent BI reports, ETL process (Extract, transform, load), etc.

2) R is a programming language that is used to study the obtained data and develop cluster analysis models.

3) VOSviewer is a software tool for building and visualizing bibliometric networks. These networks, for example, include journals, researchers or individual publications, and may be based on citations, bibliographies, citations, or co-authorship ratios. VOSviewer also offers word processing functionality that can be used to build and visualize networks of important terms that are removed from the body of scientific literature [25, 26].

4) CitNetExplorer is a software tool for visualization and analysis of citation networks of scientific publications. The tool allows you to import citation networks directly from the Web of Science database. Citation networks can be explored interactively, for example, by studying the network in detail and identifying clusters of closely related publications [26].

Examples of the use of the tools that are described above, the visualization of the results of the analysis, and evaluation of business processes of the HEI, are presented in the next section.

Examples of using tools for processing and visualization of the obtained indicators. One of the main tools for collecting, processing, and analyzing quantitative and qualitative indicators of research work of the HEI is the system "Publication" that was developed on the basis of the department of IPIEC KSU. A detailed description of the functional features and

results of the service is represented in [17-19]. As mentioned in section 4, the main task of the service is to provide automatic collection and analysis of scientometric indicators of REP, construction of ratings of REP and structural units of the university, search for publications in various scientific fields.

In addition to the functionality that was described above, the toolkit allows to conduct research and build the graphs of co-authors of individual scientists, including the total number of scientific papers (Fig. 3). This approach allows to determine the existence of joint interdepartmental, interuniversity research, which, in turn, is the degree of the synergistic component of research. For example, conducting joint research at the intersection of computer science and physics, computer science and pedagogy, cybernetics and economics, etc.

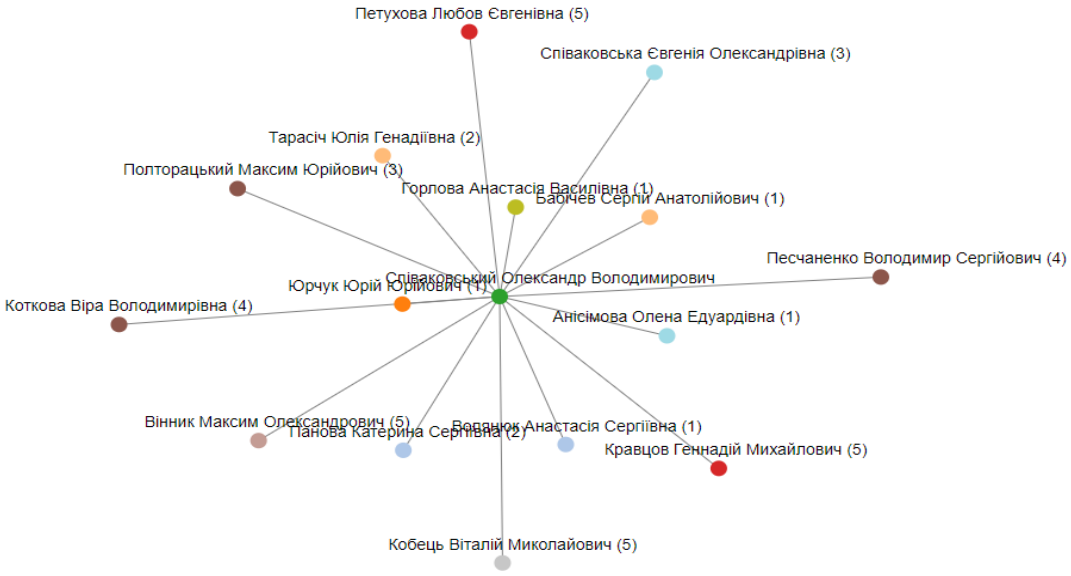

Fig.3. Graph of REP co-authors

Continuation of research on the processing and analysis of qualitative and quantitative indicators of HEI activity, the introduction of rating systems for scientific work, necessitated the expansion of the developed systems, including the system Publication, through the integration of external services and tools.

Consider the example of using Power BI to analyze the results of monitoring the activities of REP. Fig. 4 presents a generalization of the data of evaluation of the activity of research and educational personnel by the faculties and departments indicators:

The histogram of Fig.4 demonstrates the quantitative indicators of the distribution of activities of REP for each department of HEI in relation to the selected date and position. Ranking occurs in relation to such areas of activity as research, scientific-organizational, scientific-pedagogical, social-humanitarian, educational activities, the publication of scientific results, rating indicators. The percentage of quantitative indicators of the departments for each area of activity is given on the pie charts. Accordingly, there is a visualization of various indicators of individual scientists' work, author teams, HEI units.

The presentation of monitoring results graphically (Fig. 4,) allows not only to make the analysis of the obtained indicators more convenient but also provides an opportunity to find strengths and weaknesses of the monitoring system, analyze the dependence of certain indicators of REP from others. It is also important that the construction of appropriate schedules is automated - by integrating the Power BI tool into the system Publication.

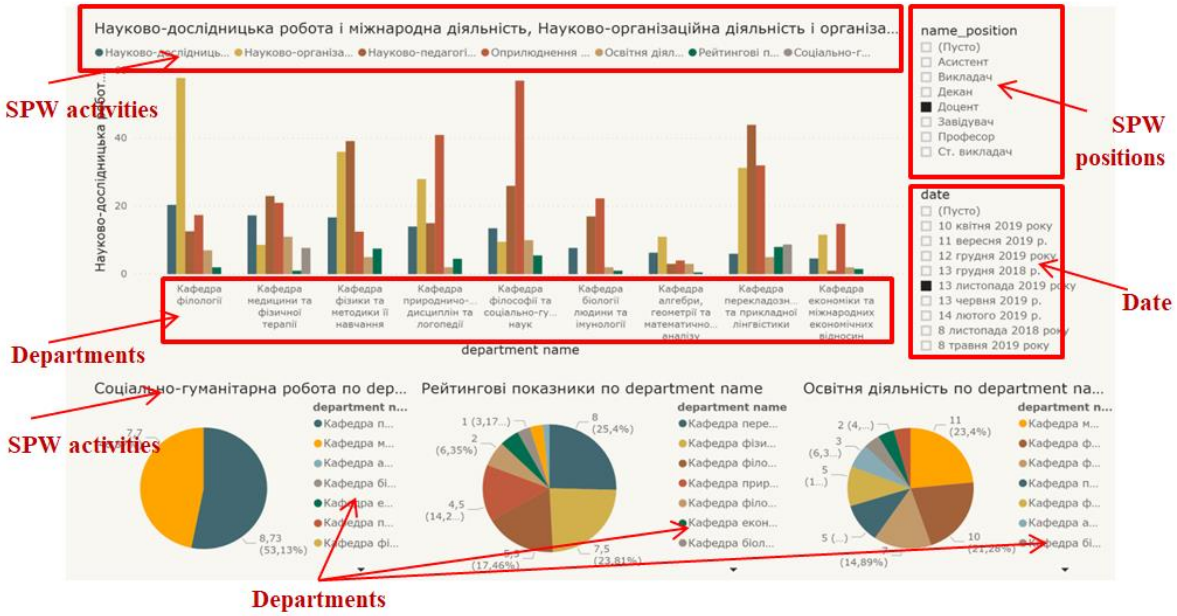

Fig. 4. Rating points by groups of indicators for evaluating the activities of REP (by departments)

In addition to the analysis of quantitative indicators of REP activity, it is important to study the openness of scientific work, the geography of approbation of scientific research. Appropriate analytics again can be displayed by the combination of the functionality of the Power BI tool and system Publication (Fig. 5).

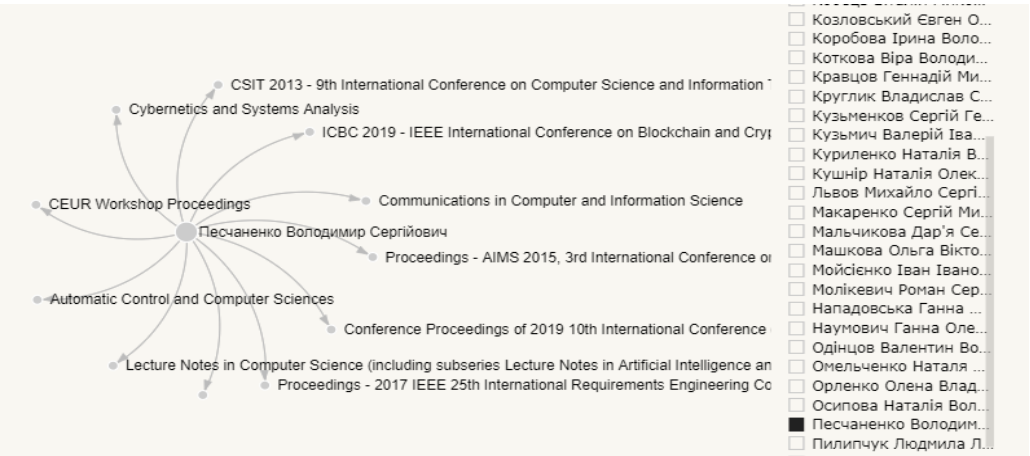

Fig.5. Geography of approbation of scientific researches (scientific journals, conferences, seminars, symposiums, etc.)

The ability to analyze relevant data (Fig. 5), allows us to analyze the level of coverage of the scientific community, the activity of the scientist, the geography of approbation of scientific research. It is important to be able to apply the relevant analysis not only to the work of a particular REP but also to research teams, departments, faculties, and the university as a whole.

An API was developed to enable the Publication system interact with other services. Thus, today we continue to develop the "Tutor-net" System and the micro-service of automated calculation of rating indicators of activity of research and educational personnel, departments, and faculties of the university according to the criteria that were described in section 3.

VOSviewer is a useful tool for visualizing qualitative indicators of REP activity. The use of this tool allows to assess the "weight" of the scientist by analyzing his publications in scientometric databases (SMDB) and systems (Scopus, WoS) (Fig.6., Fig.7.), to investigate the quantitative indicators of his scientific publications in the relevant SMDB, as well as to visualize information concerning author's collectives (Fig. 8)., subjects of scientific researches (Fig. 9).

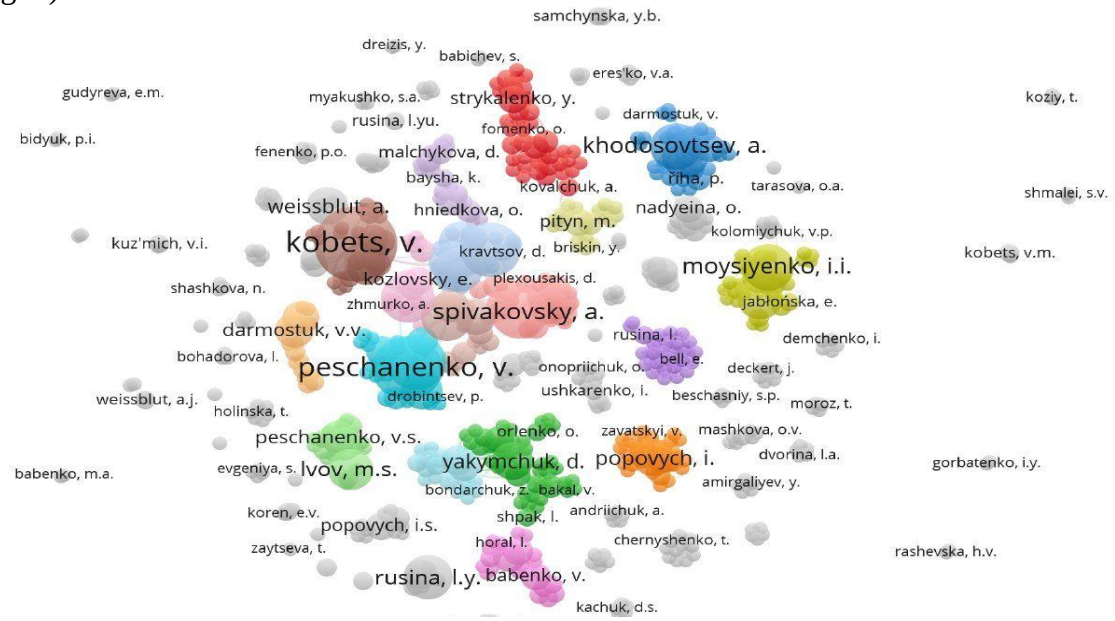

Fig.6. VOSviewer work results (Scopus)

In Fig.6, we visualize the quantitative indicators of scientific publications of REP. Data were obtained from the Scopus scientometric database. The more papers, an author has, the larger the label and the circle of the item. This allows us to evaluate the work of researchers and highlight the authors with the largest number of publications.

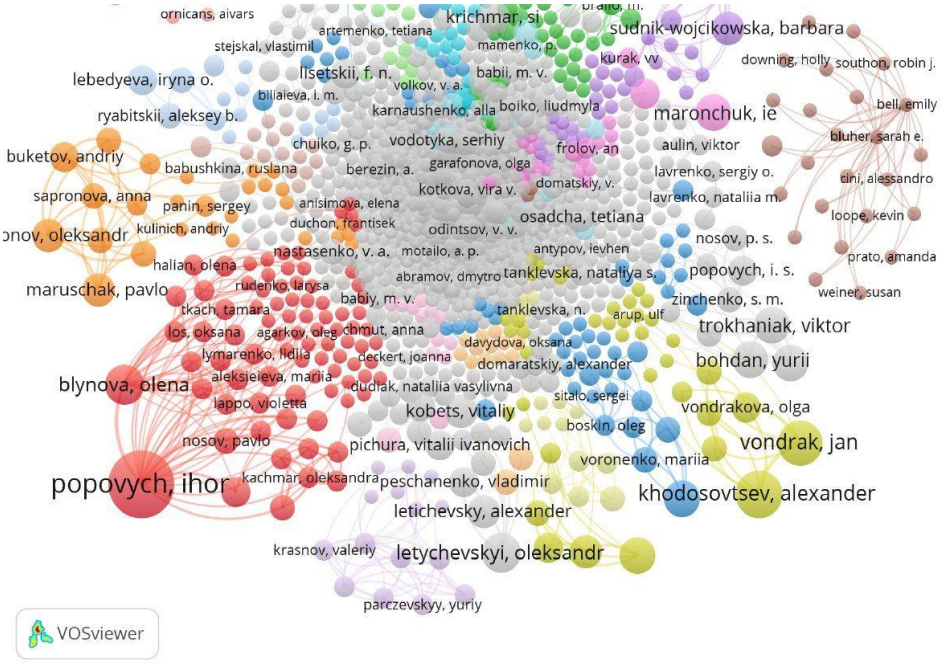

Fig.7. VOSviewer work results (WoS)

Figure 7 shows the authors with the most cooperation links with other authors. VOSviewer allows us to create a visualization of cooperation indicators between authors. The more co-authors an author has, the greater his tag. The color of an element is determined by the cluster to which the element belongs.

For example, consider the author Ihor Popovych. It has the highest label in this visualization. This means that he has the most connections with other authors. The author and co-authors form a certain cluster, which is highlighted in red. This visualization allows us to analyze research teams and to determine the center of the research team.

Figures 6, 7 demonstrate the scientists with the largest number of publications presented in the SMDB and, accordingly, the largest number of links with other authors.

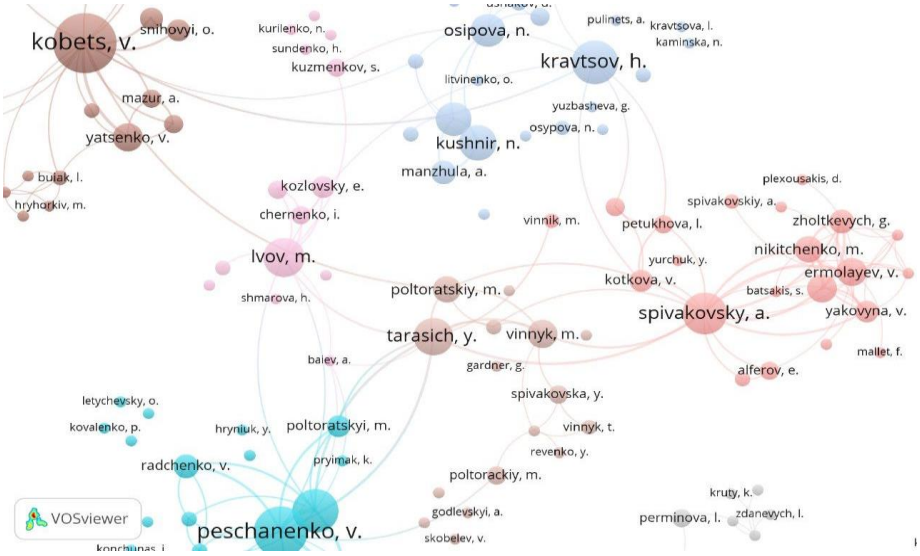

Fig.8. VOSviewer work results (Scientific teams)

In Fig.8. the HEI's scientific groups are presented. We can also evaluate the connections and intersections between these teams. A more detailed analysis will make it possible to determine the directions of research by individual scientists and the presence of joint research by scientists working in different scientific fields.

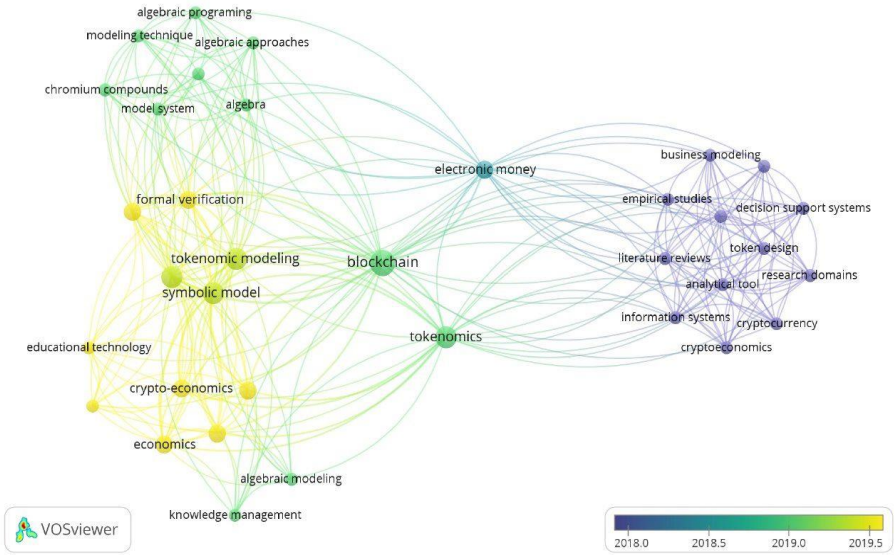

Fig.9. The results of VOSviewer work (scientist' research topics)

The visualization of the research topics of one scientist is shown in Figure 9. This allows us to evaluate the scientific areas that this author studies and the connections between them. We can also determine the most interesting topics for a given author. The larger the size of the label and the title of the topic, the more publications of the author are devoted to it. In this example such topics are blockchain and tokenomics.

Cluster analysis constitutes another important element of the analysis of qualitative and quantitative indicators of the work of HEI, in particular indicators of scientific activity. Thus, in our opinion, it is not so important for the university to monitor the dynamics of changes in scientometric indicators of individual "leading" REP, as to be able to analyze and model the dynamics of change for the entire scientific and pedagogical staff. Cluster analysis allows presenting a clearer analytical picture of the state of scientometric indicators of the entire staff of pedagogical staff of the HEI.

Accordingly, using the obtained data on the scientometric indicators of the authors (system Publication) and the language R, we obtain the following results (Fig.10).

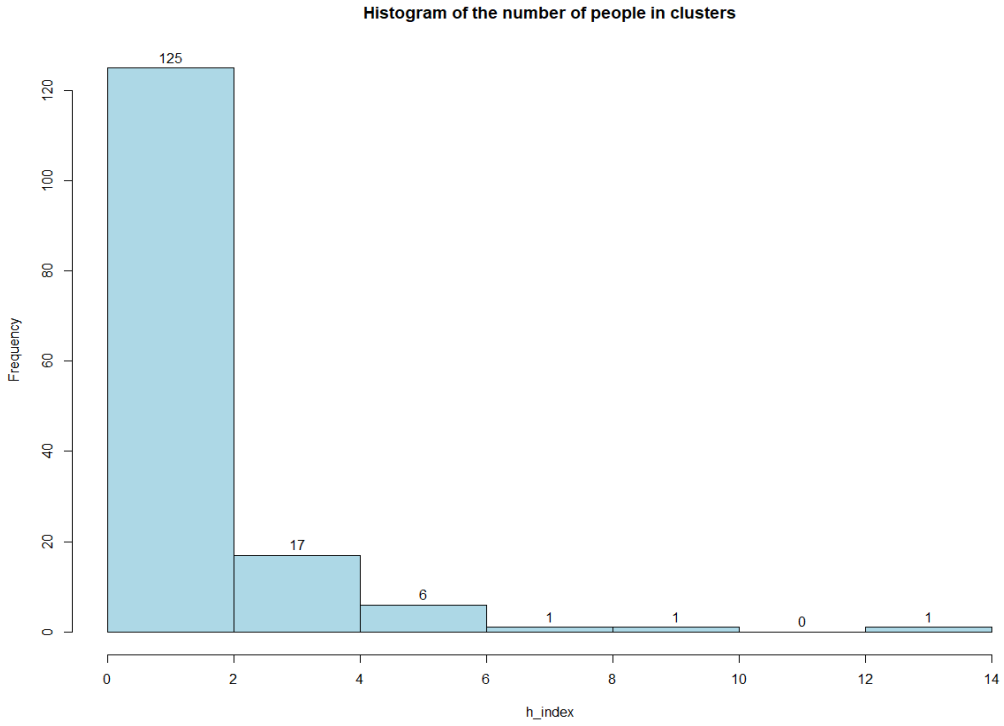

Fig. 10. Histogram of the cluster distribution of the number of REP according to the h-index

As can be seen from Fig. 10, the 1st cluster received the largest number of REP with the index h = 0 ... 1, the 2nd cluster - scientists with the index h = 2..3,…, the seventh cluster - with h = 12-13. Thus, in the fourth, fifth, and seventh clusters, there is only one scientist, in the second - 17 scientists, etc. Accordingly, comparing the relevant histograms at certain intervals (after the next update of the data of the system "Publication"), we can draw conclusions about the dynamics of qualitative and quantitative indicators not of individual scientists but of the university as a whole, given the migration of scientists between clusters.

Thus, the qualitative indicator of the scientific work of the HEI on the h-index will be determined not by the largest indicator of an individual scientist, but by the size of the largest cluster.

3. CONCLUSIONS

The problem of effective management of educational institutions remains a topical problem today. One of the important areas of management reform is the introduction of new approaches to the evaluation of key business processes of the university, the use of the latest management technologies, such as information systems that successfully integrate with proven management methods.

An important stage of this process is the constant monitoring of the development and implementation of IT in educational and business processes of the HEI, the study of changes in the university's ranking indicators in the world and domestic rankings, and their dependence on the different development strategies.

Given the main objectives of the university, and, accordingly, its "main" business processes, it is important to pay attention to the study of indicators that correspond to the educational, scientific, and international activities of the institution. Such indicators are the performance of research and teaching staff, students, PhD students. Their monitoring requires a clearly defined approach, the use of automated means of collecting, analyzing, and displaying the results.

The article identifies the "main" business processes of the university and their components; describes the approach of Kherson State University to the monitoring of indicators of the "main" business processes of the HEI; provides examples of information systems, technologies, and tools for managing business processes of the university.

Today, a system of monitoring the activities of REP has been implemented at the university, a control measurement of performance of research and teaching staff was conducted, and a method of rating assessment was introduced. Special systems and tools for automation of the main business processes of the university, in particular tools for evaluation of their qualitative and quantitative indicators, have been developed and implemented. We continue to work on the improvement and development of appropriate systems, in particular, systems that will manage the e-scientometric environment of the HEI.

The main focuses of further work are the completion of the development of an analytical information system “tutor-net”, and expanding the functionality of the System "Publication" (increasing the number of scientometric systems and databases with which the system works, expanding the functionality of the analysis of scientific journals), etc.

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ІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ ДЛЯ ВИМІРЮВАННЯ ЯКІСНИХ І КІЛЬКІСНИХ ПОКАЗНИКІВ РОБОТИ ЗАКЛАДУ ВИЩОЇ ОСВІТИ

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Анотація. Сьогодні старі методи управління трансформуються в якісно нові досягнення науки управління. Отже, питання ефективності управління навчальними закладами залишається відкритим. Одним із важливих напрямків реформування менеджменту є використання новітніх управлінських технологій, наприклад, інформаційних систем, які успішно інтегруються з перевіреними методами управління. Джерелом інформації для визначення якісних та кількісних показників роботи ЗВО повинні бути спеціальні системи та сервіси, які забезпечать обробку показників наукової, освітньої, господарської діяльності тощо. Показники та критерії їх оцінки мають бути чітко визначені та затверджені і, відповідно, розроблені спеціальні алгоритми та підходи до їх розрахунку та аналізу. Метою статті є пропонування алгоритмів та інструментів для вимірювання кількісних та якісних показників роботи ЗВО та їх реалізації на прикладі Херсонського державного університету. Зокрема в роботі розглянуто методику рейтингового оцінювання науково-педагогічних працівників, описано основні інструменти та технології автоматизації моніторингу діяльності НПП, а також приклади їх використання. Основною особливістю описаного підходу є можливість забезпечення автоматизації та відкритості основних бізнес-процесів ЗВО. Розроблені програмні засоби, інформаційно-аналітичні системи дозволяють оцінювати якісні та кількісні показники роботи закладу освіти з урахуванням його видимості на вітчизняному та міжнародному науково-освітньому просторі, які відображають результати наукової діяльності (показники за WoS, Scopus тощо), освітньої діяльності (показники успішності випускників, керівництво науково-дослідницькими роботами студентів, опитування студентів тощо).

Ключові слова: заклад вищої освіти; менеджмент університету; кількісні показники; якісні показники; наукометричні показники; рейтингові системи; інформаційні технології.

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