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DEVELOPMENT OF INFORMATION TECHNOLOGY FOR COMPLEX EVALUATION OF HIGHER EDUCATION INSTITUTIONS

Abstract. This paper presents a method for complex evaluation of higher education institutions based on a generalized volume of m-simplex calculation. Every kind of activities of higher education institutions (educational, scientific, innovative, etc.) determines an axis in the multidimensional space used to build the m-simplex. After evaluating higher education institutions in the specified m-activities, the points are put on the respective axis. M-simplex with vertices in these points is built. The generalized volume of this m-simplex, which is calculated based on the Cayley-Menger determinant, defines the integral quantitative assessment of higher education institutions' activities. To verify the specified method for evaluating higher education institutions, we reviewed well-known evaluation methods and described some types of activities that could be used as a basis for a definition of the axes on which the m-simplex is built. The research component of higher education institutions' activities is determined by the volume of articles published and their citations in international scientometric databases. The educational component relates to the quality of graduates, their competitiveness in the labour-market. The international component concerns the participation of higher education institutions and their departments in international programs and projects. The described method could be used to monitor the activities of higher education institutions and their separate structural subdivisions. The results of the monitoring are important for a comprehensive evaluation of scientific, educational, international, innovative and other types of activities of higher education institutions in a particular region and the country as a whole. In this article, we have formed a list of indicators, according to which

several Ukrainian higher education institutions were evaluated. Besides, the comparison of quantitative evaluations with ratings of higher education institutions in international systems of university activities evaluation was made.

Keywords: university rankings; higher educationm-simplex.

1. INTRODUCTION

One of the key tools for effective management of higher education institutions (HEI) is monitoring of both their overall performance and that of their structural units. Typically, monitoring of all components of the university performance, including scientific, international, educational, etc., is envisaged. An analysis of the dynamics of change in the performance makes it possible to respond timely and to adjust some aspects of the HEI development, stimulating, in particular, by increasing funding, those components of the university performance which need it. To monitor the performance of an HEI, the authors propose to create an information system, which calculates the necessary indicators automatically on a public information basis without any influence of subjective factors.

The problem statement. The core of the information technology for the HEI activities assessment is a method of calculating the integrated assessment of the HEI, taking into account different types of activities. In classical methods, there is the necessity of calculating the weighting factors influencing integrated assessment of certain types of HEI activities. The need to consider the weighting factors influencing the outcome of HEI activities makes the task of HEI activities evaluation very complex. The principle of forming weighting components, as well as the determination of estimates for particular activities, is often linked to subjective factors. Overcoming subjectivity and automating the HEI assessment process is an important objective of this study. Investigation of calculation methods for complex assessments of HEI, search for sources and methods for obtaining calculation indicators, determination of specific types of HEI activities are important for the national system of higher education.

Analysis of recent studies and publications. The first step to build an info-communication system for evaluation of HEI activities is by determining key performance indicators. Important indicators of higher education institutions activities that could be used to build a comprehensive assessment are the number of academics' scientific publications indexed in scientometric bases and their citation rates. Often, classic citation indexes are used to calculate these indicators: h-index, g-index, etc. Some of these indices are described in papers [1–3]. The paper [4] describes the application of an ideal point method for evaluating the activity of individual scientists, the coordinates of which are estimates of the results of these scientists' research activities. Possibilities of transition from qualitative assessment of higher education institution performance to quantitative one is described in the paper [5]. However, the disadvantage of this transition is the necessity to use the peer review method, which involves a significant impact of subjective factors on the process. The paper [6] describes the use of the ideal point method for an adaptive choice problem. Expert methods for evaluating research activities have been described in the papers [7, 8]. The main disadvantage of the methods is ignoring information about links between publications. In the paper [9], a model for evaluating higher education institutions' activity is considered, which makes it possible to accomplish the transition from university evaluations to forecasting the prospects of their development in the future. The paper [10] describes the method for predicting the research potential of universities. However, it should be noted that to evaluate the potential of a higher education institution. It is necessary to consider the whole range of its activities: scientific, educational, international, innovative, etc.

The NAHEQA [11] report describes the method of calculation for performing the integral indicator of HEI comparative criteria. However, the rating built as a result contains a significant number of close estimates, making comparisons difficult. Besides, the assessment is based on reports submitted by HEI that include inaccuracies or unreliable data. According to the authors, while constructing the HEI estimates, it is necessary to avoid the influence of subjective factors and to use only open sources of information. According to the NAHEQA recommendations, the only effective way is to create an electronic system of data entry and analysis.

Information technologies that are based on the methods and models discussed above need the influence of experts on the formation of estimates. An urgent goal of the researches is to build assessment information technologies to minimize the involvement of experts, thereby to reduce the subjective factors of assessments. Such systems can be an effective tool for HEI managing.

In [12], the authors described the method for HEI activity evaluation based on the calculation of the generalized volume of the m-simplex. Information technology was developed to conduct an HEI assessment, including the specified method. In the development of information technology, the authors had focused on the evaluation of the scientific component of the HEI activity. An essential task of the researches is to develop the information technology in terms of selection of other components of the HEI activities (international, educational, etc.) and their consideration in a complex assessment.

The article's goal. The purpose of the article is to develop the information technology for complex evaluation of HEI by exploring the possibilities of inclusion in the complex evaluation of various HEI activities and sources of obtaining indicators for the activities results.

To accomplish the goal, the following tasks have been set:

1. Consideration of existing methods of evaluating the activities of higher education institutions.
2. Description of the method for evaluating the results of the HEI activity based on the calculation of m-simplex generalized volume.
3. Consideration of the constituents of the HEI activity affecting the quality of learning tools, the evaluation of which is based on the calculation of m-simplex generalized volume. For this purpose, it is necessary to develop a method of determining the estimates for the activities, as well as to identify reliable open sources for collecting relevant information on the activities results.
4. Testing of the developed information system in terms of rating construction of selected Ukrainian HEI based on the developed method.

2. THE THEORETICAL BACKGROUNDS

2.1. Review of international methods used for evaluating activities of higher education institutions

There are several international systems for evaluating HEI activities. The most reputable among them is the World University Ranking of the British consulting company Quacquarelli Symonds (QS) [13] and the Academic Ranking of World Universities, called the Shanghai Ranking Consultancy (also known as the Shanghai Ranking) [14].

The indicators taken into account when calculating the respective rating and their relative weight are presented in the tables below.

Table 1

QS rating

Type of activity	Indicators	Relative weight,%
Academic	– Academic Reputation – H Index – Citations per Faculty – Staff with PhDs	40
Employer	– Employer Reputation – Employers' Presence on Campus – Graduate Employment Rate – Alumni Outcomes	20
Study	– Number of staff to the number of student Radio – Student exchange inbound	30
International	– The proportion of faculty members are international.	10

Table 2

Shanghai Ranking

Type of activity	Indicators	Relative weight,%
Quality of Education	– Alumni as Nobel laureates & Fields Medalists	10
Quality of Faculty	– Staff as Nobel Laureates & Fields Medalists – Highly Cited Researchers	20 20
Research Output	– Papers published in *Nature* and *Science* – Papers indexed in Science Citation Index-Expanded and Social Science Citation Index	20 20
Per Capita Performance	– Per capita academic performance of an institution.	10

The Ranking Web or Webometrics has the broadest coverage among HEI. It aims to build a rating for all HEI in the world, not just the hundreds or thousands of the most developed ones. The rating has been built twice a year by the Cybermetrics Lab (Spanish National Research Council, CSIC) since 2004. The rating is based on the web presence and impact of the HEI [15], evaluates the HEI website, its design or convenience, and the number of visits or unique visitors. Web indicators are seen as a proxy for assessing the university's global performance and impact. The Webometrics assessment methodology is constantly evolving and improving. This rating is significantly different from the other ratings, which focus on the evaluation of bibliometric indicators and favor the scientific component of the HEI activity. Webometrics focuses on economic activity, the use of information technology for industry, community involvement (social, cultural, environmental components of HEI activities), and even its political influence.

Webometrics believes that link analysis for quality evaluation provides a broader coverage of HEI activity than citation analysis or expert surveys. This rating motivates scientists and HEI to increase and improve their Web presence. Web presence contributes to the dissemination of knowledge and a more objective evaluation of performance through public discussion. Webometrics uses a priori model to find the overall metric. This methodology takes into account the power-law distribution of the data. All indicators are divided into two groups: activity/presence and visibility/impact. Each of these groups is equivalent, and as a result, it gives half of the overall assessment of the HEI.

An analysis of the HEI assessment methods shows that they take into account different indicators. In 2019, the only HEI in Ukraine that was included in the QS rating was V.N. Karazin Kharkiv National University (491–497 position in the rating). The QS rating gives a diverse assessment of the HEI performance. Most of the indicators taken into account when calculating a rating are objective and could be obtained from relevant open sources. Some indicators are subjective, such as reputation indexes. To obtain them, a sufficient number of qualified experts should be interviewed, which is a non-trivial task. Assessment by the QS rating method encourages the development of relationships between the HEI and active project collaboration.

Unfortunately, not a single Ukrainian HEI is among the Top 500 HEI in the Shanghai rating for 2003-2017 and the Top 1000 for 2018 and 2019. The Shanghai rating focuses on the results of HEI scientific activities. The Shanghai rating includes only those HEI, graduates of which are Nobel or Fields Prize winners, which is a significant impediment to its use. If these items are excluded from consideration, the methodology can be used for evaluation of the performance of Ukrainian HEI. In our opinion, the Shanghai rating methodology is more appropriate for the evaluation of research institutions.

The insignificant representation of Ukrainian HEI in international rankings indicates the necessity to develop our own HEI assessment methods that would be based on the same indicators. Such methods encourage HEI to develop and improve relevant indicators.

2.2. Review of the national methods for evaluating the HEI activity

Since 2007, the Center for International Projects "EuroEducation", in partnership with the international expert group IREG Observatory on Academic Ranking and Excellence, have been annually presenting academic rating of the Ukrainian higher education institutions of the 3rd and 4th levels of accreditation "Top 200 Ukraine" [16]. The methodology of the Top 200 Ukraine project is created following the Berlin University Ranking Principles. It is based on using open data of direct measurements and expert opinions of specialists in higher education and major labor markets of Ukraine. Indicators and their importance are shown in Table 3.

Table 3

TOP 200 Ukraine

Type of activity	Indicators	Relative weight,%
Assessment of the scientific and pedagogical potential	- Teaching staff - Representation in international rankings - Awards of the Committee on State Prizes of Ukraine and T. Shevchenko Prizes	40
Assessment of the education quality	- Average competitive score of the entrant	25
Assessment of international recognition	- Academic mobility - HEI participation in international projects (Horizon 2020, Erasmus +) - HEI participation in NATO-funded projects under the Science for Peace and Security Program - HEI participation in bilateral projects	20
Expert assessment	- level of basic, general education of students - level of professional training - level of information technologies practical knowledge - HEI graduate employment rate	15

The known international and national methods of evaluating the activity of higher education institutions were reviewed: QS, Webometrics, Shanghai Rating, TOP 200. The specifics of calculating the assessments by these methods and the possibility of their use for the evaluation of Ukrainian HEIs are indicated. The necessity of the creation of a new methodology for rating calculation, which takes into account the peculiarities of the Ukrainian HEIs activity, without losing the advantages of the known, recognized by the scientific community, methods, is pointed out. The activities that should be considered when creating a new methodology are defined.

2.3. Methodology for obtaining integral evaluation

The authors propose a new method for calculating the integral estimate based on the computation of the generalized volume of the m-simplex.

Let $K_0, K_1,\ldots, K_m$ be different types of HEI activity, where m is the number of HEI activity types. Each activity is characterized by indicators $\Pi_1,\Pi_2,\ldots,\Pi_{k_i}, i=\overline{1,m}$, where (m+1) is the number of activity types, and k_i is the number of indicators characterizing the K_i activity type. Then a comprehensive evaluation of the HEI activity is carried out according to the following scheme:

1. Determination of indicators $\Pi_1,\Pi_2,\ldots,\Pi_{k_i}$, which characterize the respective HEI activity K_i for $i=\overline{1,m}$.

2. Finding the values of indicators $\Pi_1,\Pi_2,\ldots,\Pi_{k_i}$ the result of HEI activity for the period T = $[t_0, t_1)$, where t_0 is the initial time point, t_1 is the end time point.

3. Calculation of result estimates for different types of HEI activities over the period T = $[t_0, t_1)$.

There are different methods for calculating result estimates of a particular HEI activity. The weighted coefficients method is based on the above methods of the HEI activity estimating (QS, Shanghai, TOP 200 Ukraine).

The method of weighted coefficients is described by the coefficients ω_j, $j=\overline{0,k_i}$, for which the condition $\sum_{j=0}^{k_i}\omega_j=1$ is satisfied. Each of these coefficients, ω_j, $j=\overline{0,k_i}$, reflects the importance of the indicator Π_j when evaluating the results of a particular type of HEI activity. The formula presents the results of HEI activities:

$$Q_i^T(S)=\sum_{j=0}^{k_i}\omega_j\Pi_j^T(S), \quad (1)$$

where $\Pi_j^T(S)$ is the value of the indicator Π_j of HEI S over the period T=$[t_0, t_1)$, $Q_i^T(S)$ is K_i estimate value of the HEI type of activity.

The ideal point method is based on the presentation of the results of the HEI activity in a multidimensional space and the distance to the ideal point. The values of the indices $\Pi_j^T(S)$, $j=\overline{0,k_i}$ are considered as coordinates of the point $F^T(S)\in R^{k_i}$ in (k_i+1)-dimensional space. The ideal point is the following point $F^*=(\Pi_0^*,\Pi_1^*,\ldots,\Pi_{k_i}^*)$ in (k_i+1)-dimensional space for which the condition holds:

$$\Pi_b^*\geq\Pi_b^*(S), b=\overline{0,k_i}. \quad (2)$$

The formula presents the results of the HEI activities:

$$Q_i^T(S) = \rho(F^T(S), F^*), \tag{3}$$

where ρ is the Euclid distance, Minkowski distance, etc.

In the paper [12], the authors propose for the HEI estimation calculating the generalized volume of the m-simplex. The m-simplex with vertices at points $\nu_i \in R^{m+1}$ is called an m-dimensional polytope, which is a convex shell of its *m+1* vertices. The generalized volume of the m-simplex $V(\Delta^m)$ is a numerical characteristic that determines the capacity of a part of the space bounded by this m-simplex. The generalized volume of the m-simplex is calculated by the Kelly-Menger formula.

We apply this method to comprehensively evaluate the results of the HEI activities. We assign to each activity K_i, $i = \overline{1,m}$ a point in the *(m+1)* - dimensional space ν_i according to the rule:

$$\begin{aligned} \upsilon_0 &= (Q_0^T(s), 0, 0, \ldots 0) \\ \upsilon_1 &= (0, Q_1^T(s), 0, \ldots 0) \\ &\vdots \\ \upsilon_m &= (0, 0, \ldots, 0, Q_0^T(s)) \end{aligned} . \tag{4}$$

Let us construct an m-simplex with vertices at ν_i, $i = \overline{1,m}$ and find its generalized volume by the Kelly-Menger formula. Complex estimate of the $Q^T(S)$ of the HEI S activity over the time period *T* could be found by the formula:

$$Q^T(S) = V(\Delta^m), \tag{5}$$

where $V(\Delta^m)$ is generalized volume of the m-simplex, with vertices at points (4).

Method of complex estimation of the HEI activity results based on the calculation of the m-simplex generalized volume, in contrast to the method of ideal points, does not require the selection of the point the coordinates of which are estimates of activities of HEI that is the best in terms of maximum performance by some criteria. If the coordinates of the point selected are very small, the result of the evaluation may lead to the emergence of the point with coordinates larger than the ideal point has. Besides, it would be contrary to the definition of an ideal point. Moreover, if the coordinates of the ideal point to determine are too large, the distance between the points, which are the estimates of HEI activities, would vary by a negligible amount, which would make comparison difficult.

In contrast to the method of weighted coefficients, the method of complex estimation of the activity results of HEI based on the calculation of the m-simplex generalized volume does not require the selection of these weights. The authors criticize other Webometrics rankings for the use of the method of weighted coefficients [15]. Often situations arise when certain indicators differ from zero one only for a few HEI. This situation distorts the results of the final HEI assessment. It also opens up opportunities for speculation and adjustment of the results. This problem is particularly relevant for countries which do not yet have strong academic tradition, including Ukraine.

Another significant problem is the estimation of the HEI having a different scale. Using absolute values does not allow adequate comparison. The traditional approach is the valuation indicators on the number of students or the number of employees. However, such approaches also have drawbacks. A much better approach is taking into account the power-law distribution of the data. By this law, a logarithmic scale is used to eliminate the effect of scale.

3. RESEARCH METHODS

Information technology of complex evaluation of HEI activity includes:

1. Collection of indicators from reliable open sources of information.
2. Calculation the estimates of the HEI activities.
3. Complex evaluation of HEI based on the method of calculating the generalized volume of the m-simplex.

Traditionally such components of the HEI activities are singled out: educational, scientific and innovative. Estimates of these components could be considered as points on each of the m-axes on which the corresponding m-simplex is constructed. The generalized volume of m-simplex is a quantitative integral evaluation of the higher education institution activity. To calculate the coordinates of points that are placed on the axes, it is necessary to obtain the values of the indicators characterizing the respective activities. Let us take a closer look at each type of activity and identify the relevant metrics. These estimates are used to improve the second component of information technology. Open sources of information would be considered to determine indicators. These sources are used to improve the first component of information technology.

3.1. Research component of higher education institutions activities.

The definition of scientific activity as a creative intellectual activity aimed at obtaining new knowledge and (or) search for ways of its use, the main types of which are fundamental and applied research, is given in the law of Ukraine "On scientific and scientific-technological activities". Besides, the law states that a scientific result is the new scientific knowledge gained in the process of fundamental or applied research and recorded on information carriers. A scientific result can be in the form of a report, a published scientific paper, monographic studies, a scientific discovery, a draft of a normative legal act, a normative document or a scientific-methodological document, preparation of which requires the appropriate scientific study or contains a scientific component [17].

To ensure the efficiency of the complex evaluation of the results of scientific activities, it is important to organize a database, a repository, an electronic library to store these results. Knowledge transformation objects and channels for disseminating scientific results are scientometric databases. Analysis of scientometric databases makes it possible to evaluate the scientific activity of a scientist, a group of scientists, a university, and even a country or its region.

Among the huge number of scientometric databases, the two most prominent are the Web of Science [18] and Scopus [19]. Some major publishers are also building their commercial scientometric databases: Springer, Begell House Inc., Thomson Reuters (ISI), Web of Knowledge, Pleiades Publishing, Kluwer, and others. Among the non-commercial science-based databases the following bases could be mentioned: SORRNICUS [20]; BASE [21]; eLibrary.ru (Scientific Electronic Library) [22]; DOAJ [23]; Driver [24]; FreeFullPDF [25]; UlrichsWeb [25]. Search engines Publish or Perish, and Google Academy [27] may also be useful for evaluating research results.

3.2. The educational component of the HEI activities

Attractiveness to the entrants is one of the important components of the HEI educational activity evaluation. It is expressed through the entrant's desire to be enrolled in the HEI. Attractiveness to the entrants could be assessed through the analysis of entrants' applications.

The latest information on entrants' applications can be found at EDEBO [28]. Important parameters are the total number of applications and the number of applications with the

highest priority. It is also important to know the number of students enrolled on the budget and contract basis.

Another indicator is the students' potential, as determined by the input set of knowledge at the moment of admission to the HEI. Evaluation of this potential is possible by taking into account the HEI competitive entrance score adjusted for each particular specialty. In 2019, the highest average score of entrants was shown by specialty 112 "Statistics" – 181,18 points, and the lowest by 261 "Fire safety" – 131,48 points. The ratio of the entrant's competitive level to the average score of the specialty shows his/her potential. Having calculated the average value for all the HEI students, it is possible to estimate the average potential of the HEI students. The result is a positive number, which we call the coefficient of potential of the HEI students. In case the ratio is less than 1 the students' potential is low. In case the ratio is equal to 1 the students' potential is average. In case the ratio is higher than 1 the students' potential is high. However, the average potential of the HEI students is a quantitative assessment of this HEI.

3.3. The international component of the HEI activities

An extremely important is the interaction of the HEI with other universities abroad. One of the most important components is the interaction within international programs. Data on the HEI participation in programs can be obtained on the website of the National Erasmus+ Office in Ukraine [29]. This portal contains information on ongoing and completed projects under the Tempus, Jean Monnet, Erasmus Plus programs. To evaluate the international component of the HEI activity, it is important, in addition to the number of international projects in which the HEI is involved, to determine the amount of funding for these projects. It would allow one to calculate a quantitative assessment of this component.

4. THE RESULTS AND DISCUSSION

To verify the results of the study, the selected indicators of the HEI activities from reliable public sources were selected. This information was included in the designed information system for the evaluation of the HEI activities. The system works in a test mode and is being developed as part of the state budget research "Development of the methods for analysis of quality of research work of scientists, HEI of the Ministry of Education and Science of Ukraine and their structural departments" in Taras Shevchenko Kyiv National University. A full version of the publicly accessible system will be launched in 2021. The system modules related to the filling of the database with information on scientific, international and educational activities, as well as the calculation of complex assessment based on the calculation of the generalized volume of the m-simplex, already have been implemented. The system complements and expands the info-analytical system "Database of Scientists of Ukraine". The methods of collecting and structuring the information on research results from open sources, as well as the system modules are described in the paper [30]. The database contains over 600,000 records of key indicators publication activity of Ukrainian HEIs. Indicators on the international and educational activities of the HEIs were obtained from open sources and entered into the info-communication system for the study. Based on the method of integrated evaluation of higher education institutions implemented in the system, a rating was built for the five selected HEIs: V. N. Karazin Kharkiv National University (KhNU), Taras Shevchenko Kyiv National University (KNU), Kyiv National University of Construction and Architecture (KNUCA), State Higher Educational Institution "Uzhhorod National University (UzhNU) and Lesya Ukrainka Eastern European National University (EENU). The results are summarized in Table 4.

Table 4

Results of the Ukrainian HEI

Index	HEI					Constituent
	KNU	KhNU	KNUCA	UzhNU	EENU	
Number of SciVerse Scopus Scientometric Database Publications as of April 17, 2019	17239	9408	238	2230	766	Scientific
Number of citations	98814	54178	880	10700	5225	
Hirsch index	89	70	15	37	28	
Average standardized evaluation	**100**	**62.68**	**6.38**	**21.78**	**13.73**	
TEMPUS IV projects in 2019	11	6	3	4	1	International
CBHE (KA2) projects in 2015-2019	5	3	1	1	1	
CBHE (KA2) total grant (thousands Euro)	4039,7	2388,3	811,2	789,5	954	
KA1 International Credit Mobility (ICM) projects 2015-2018	171	80	10	46	15	
Jean Monnet 2014-2018 EU Grant (thousands Euro)	59,5	30	0	0	24,7	
Average standardized evaluation	**100**	**52.11**	**8.64**	**15.48**	**24.63**	
Number of applications for BA programs	41285	18857	5295	6732	7955	Educational
Number of applications for BA programs with a top priority	6171	2443	860	1075	1269	
Number of government-subsidized students enrolled in BA programs	4845	1058	1103	1400	1381	
Student's potential factor	1.081	1.119	0.979	0.973	1.005	
Average standardized evaluation	**98.87**	**53.81**	**41.40**	**44.42**	**46.29**	
Ranking WEB of Universities, position.	1995	2245	5449	3527	11415	Complex
Top 200, 2019, points	78,03	47,00	22,57	23,70	18,44	
NAHEQA, integral indicator	5,21	13,12	0,31	1,11	1,19	
Complex HEI evaluation	**53.18**	**34.29**	**10.28**	**16.65**	**17.44**	

The weighted estimation method was used to calculate the average standardized assessment of the scientific, international and educational constituents of the HEI activities. Before applying this method, each of the indicators was normalized to the maximum value of the corresponding indicator. Besides, for convenience of perception, scaling was performed with a scaling factor of 100. A comprehensive HEI estimation was made by calculating the summed volume of 3-simplex in the corresponding three-dimension space.

The study showed a correlation between the results obtained by the developed method with other known methods of estimating HEI activity. But the sample with five universities is insufficient for more in-depth analysis.

For the complete analysis of the HEI, in addition to the data provided, it is also necessary to calculate indicators for other activities. In particular, it is necessary to gain increased access to EDEBO data, report of the Ministry of Education and Science on the HEI participation in government-funded research activities, etc. This is the prospect of further research.

5. CONCLUSIONS AND PROSPECTS FOR FURTHER RESEARCH

The method for estimation of the HEI activity results based on the calculation of m-simplex generalized volume is described. The main feature of the method is to minimize the

influence on the calculation of subjective factors and to use information from reliable open sources for the calculation.

To use the method for estimation of the HEI activity results based on the calculation of m-simplex generalized volume, educational, scientific, international, innovative and other components of the HEI activities should be evaluated. The educational component of HEI activity is considered in terms of its assessment by entrants. It is suggested to take into account the student's potential factor, which represents the average competitive score of HEI applicants and characterize the popularity of the External independent evaluation, to evaluate the educational component of the HEI for potential entrants. The method is a mathematical core of information technology for the assessment of the HEI in terms of calculating the assessments of the components of the HEI activity. For a complete reflection of the educational component of the HEI activity, it is necessary to consider indicators that directly characterize learning outcomes.

Open sources were analyzed in terms of accessibility of HEI activities indicators. Indicators for the educational, scientific and international components of HEI activities can be obtained in sufficient volume from reviewed open sources. It makes possible to develop the information technology in terms of automation of gathering information on the educational and international components of the HEI activities. To get indicators for other components of HEIs activities, it is necessary to access closed sources or to analyze own reports of HEI. The research did not take into account some components of the HEI activities, such as the innovation and staff components. In the evaluation of the international component, the participation in educational projects such as Erasmus+, but not scientific projects and programs, was taken into account. The further task is to find other sources for indicators of HEIs activities. To evaluate non-Ukrainian universities, it is also necessary to identify additional open sources.

The results obtained allow us to conclude that the above methodology can be effectively used for the evaluation of higher educational institutions. In the future, it is proposed to carry out a thorough analysis of all Ukrainian HEIs with the help of the evaluation information system to form their general rating.

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РОЗРОБКА ІНФОРМАЦІЙНОЇ ТЕХНОЛОГІЇ КОМПЛЕКСНОГО ОЦІНЮВАННЯ ДІЯЛЬНОСТІ ЗАКЛАДІВ ВИЩОЇ ОСВІТИ

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Анотація. У статті розглянуто метод комплексного оцінювання закладів вищої освіти на основі обчислення узагальненого об'єму m-симплексу. Кожен з видів діяльності закладу вищої освіти (освітній, науковий виховний, інноваційний тощо) задає осі простору, у якому будується m-симплекс. Після оцінювання закладу вищої освіти за вказаними m видами діяльності проставляються точки на відповідних осях та будується m-симплекс. Узагальнений об'єм даного m-симплексу, що розраховується на основі формули Келі-Менгера, визначає інтегральну кількісну оцінку діяльності закладу вищої освіти. Для верифікації вказаного методу оцінювання діяльності закладу вищої освіти було розглянуто відомі методи оцінювання та описано деякі види діяльності, що можуть братися за основу при визначенні осей, на яких будується m-симплекс. Наукова складова діяльності закладу вищої освіти визначається обсягом опублікованих статей та їх цитуванням у міжнародних наукометричних базах даних. Навчальна складова охоплює підготовку фахівців з відповідних спеціальностей, їх затребуваність на ринку праці. Міжнародна складова стосується участі закладу вищої освіти в міжнародних програмах та проєктах. Описаний метод може бути використаний для моніторингу результатів діяльності закладів вищої освіти та їх окремих структурних підрозділів. Результати моніторингу є важливими для комплексного оцінювання не тільки стану забезпечення всіх складових діяльності конкретного закладу вищої освіти, але й стану наукової, навчальної, міжнародної, інноваційної та інших видів діяльності закладів вищої освіти конкретного регіону та держави в цілому. У статті було вибудувано перелік показників, за якими було оцінено декілька українських закладів вищої освіти. Також наведено порівняння отриманих кількісних оцінок з оцінками цих закладів вищої освіти в міжнародних системах оцінювання діяльності університетів.

Ключові слова: рейтинг університетів; вища освіта; m-симплекс.

РАЗРАБОТКА ИНФОРМАЦИОННОЙ ТЕХНОЛОГИИ КОМПЛЕКСНОГО ОЦЕНИВАНИЯ ДЕЯТЕЛЬНОСТИ ВЫСШИХ УЧЕБНЫХ ЗАВЕДЕНИЙ

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Аннотация. В статье рассмотрен метод комплексной оценки высших учебных заведений на основе вычисления обобщенного объема m-симплекса. Каждый из видов деятельности высшего учебного заведения (образовательный, научный, воспитательный, инновационный и др.) определяет оси пространства, в котором строится m-симплекс. После оценки указанных m видов деятельности высшего учебного заведения наносятся точки на соответствующих осях и строится m-симплекс. Обобщенный объем данного m-симплекса, рассчитываемый на основе формулы Келли-Менгера, определяет интегральную количественную оценку деятельности учреждения высшего образования. Для верификации указанного метода оценки деятельности учреждения высшего образования были рассмотрены известные методы оценки и описаны некоторые виды деятельности, которые могут браться за основу при определении осей, на которых строится m-симплекс. Научная составляющая учреждения высшего образования определяется объемом опубликованных статей и их цитированием в международных наукометрических базах данных. Учебная составляющая касается подготовки специалистов по соответствующим специальностям и их востребованности на рынке труда. Международная составляющая касается участия учреждения высшего образования и его структурных подразделений в международных программах и проектах. Описанный метод может быть использован для мониторинга результатов деятельности высших учебных заведений и их отдельных структурных подразделений. Результаты мониторинга важны для комплексной оценки не только состояния обеспечения всех составляющих деятельности конкретного учреждения высшего образования, но и состояния научной, учебной, международной, инновационной и других видов деятельности высших учебных заведений конкретного региона и государства в целом. В статье построен перечень показателей, по которым было оценено несколько украинских высших учебных заведений. Также приведено сравнение полученных количественных оценок с оценками этих учреждений высшего образования в международных системах оценки деятельности университетов.

Ключевые слова: рейтинг университетов; высшее образование; m-симплекс.