Development of Infocommunication System for Scientific Activity Administration of Educational Environment's Subjects

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***Abstract*—Publication considers main aspects of infocommunication system development for scientific activity administration of educational environment's subjects on the basis of scientific activity results in project-vector space presentation. The method of administrative influence vector constructing is proposed, which allows to increase the efficiency of scientific research projects results achievement by more accurate and timely application of administrative influence means. Developed information technology makes it possible to simplify the management of educational environment's subjects by identifying the aspects of activity that need to be influenced. The integration of technology with micro-service evaluation of scientific research results "The base of scientists of Ukraine" is presented.**

***Keywords*—project-vector methodology; project management; educational environments.**

I. Introduction

Formation of a quality management system for scientific and educational activity of educational institutions on the profiles of value, which is created for educational projects with the transition from one-dimensional to multidimensional evaluation systems is an urgent need for the modern development of education sphere both in Ukraine and in the world [1–6]. Known methods of planning, administration and evaluation of research activities in higher educational institutions do not allow full, objectively reflect the results of work, which leads to the adoption of inefficient managerial decisions [7–11]. Imperfection of tools for solving the main tasks of project-vector methodology in the part of evaluation and planning of educational environment subject's activities constrains the development of theoretical and practical base in this direction [12–14]. In this regard, the study aimed at creating of applied information technologies for the application of project-vector management methodology for the task of administering, planning and evaluating the activities of educational environment subjects is relevant.

Subjects of educational environments (SEE) are scientists, higher educational institutions and structural subdivisions: institutes, faculties, departments, groups of scientists, united by the implementation of a particular project, etc. Information of SEE activity's results is often unstructured, incomplete, obtained from various sources. Also, the classical methods for evaluating of scientific activity results are characterized by low sensitivity to changing parameters [15]. Application of well-known methods for evaluating, planning and administering see activities has certain limitations in these conditions, therefore, there is a need to improve methods taking into account the features of research activities.

The research objective is to create an infocommunication system for scientific activity administration of educational environment's subjects on the basis of project-vector model for presenting the results of scientific research in affine space.

To achieve the objective, the following tasks were set:

- to develop methods for calculating the motion vectors and administrative influence in the project-vector space;
- to create an infocommunication system for SEE's scientific activities administration;

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- to integrate the developed system with the micro-services of information and analytical system "The base of scientists of Ukraine".

II. THE PRIMARY RESEARCH MATHERIALS

Let K_0, $K_1,\ldots$, K_m are categories that reflect different aspects of SEE S scientific research. Each category of indicators determines a certain criterion, which evaluates the results of scientific activities of SEE such as: publication activity, international cooperation and exchange of experience, implementation of research results in practice, etc. We formalize the process of scientific research results presenting in vector space. We denote by $\Pi_0, \Pi_1, \ldots, \Pi_{k_i}$ are indexes for category ratings K_i, $i = \overline{0,m}$, where $(m+1)$ is the number of categories, and k_i is the number of indicators that belong to category K_i.

Evaluating the results of each aspect of scientific activity is based on indicators $\Pi_1, \Pi_2, \ldots, \Pi_{k_i}$, belonging to the appropriate category K_i, $i = \overline{0,m}$. Methods for obtaining the values of indicators from open sources that are presented on the Internet are described in the publecations [15, 16]. To evaluate the performance of some SEE S over a period of time $T = [t_0, t_1)$, where t_0 is initial time point, t_1 is finish time point, it is necessary to determine the numerical indicators values of the subject for relevant period. In practical tasks, it is usually advisable to consider time as a discrete value, because the evaluation of scientific activity results is carried out with a certain periodicity, for example, year, quarter, month, etc. Denote by $\Pi_j^T(S)$ is the numerical value of indicator Π_j of subject S for the period $T = [t_0, t_1)$. Indicators $\Pi_j^T(S)$ can be both absolute and relative. Some of the indicators, such as the number of professorial teaching staff awards, should be standardized according to the number of all staff members of higher education institutions (HEI). Some of indicators should be normalized by the number of HEI students. In general, this is a separate task of research and it is not considered in this article.

Methods for the results of the subject S on the criteria K_i, for the period of time T=[t_0, t), namely: the method of weight coefficients, the method of an ideal point, the method for calculating the generalized volumes of m-simplexes of evaluation [17]. Using one of these methods, we calculate the estimates of the results of the subject S, found by criteria K_i, $i = \overline{0,m}$, for the period of time T. And let's designate them through $Q_i^t(S)$.

In some m-dimensional affine space, we construct a point with coordinates $Q = \left(Q_0^t(S), Q_1^t(S), \ldots Q_m^t(S)\right)$, which corresponds to evaluation of scientific activity results SEE S at the time t_1. Estimates of various aspects of scientific activity results of SEE S $Q_i^T(S)$ are projections of Q point, which reflects the results of scientific research at the time t_1, on the axis $(m+1)$- dimensional affine space.

If you consider the research activities of the SEE for the period T as a project, then Q-point represents the state of the project at the time $t \in T$, and the trajectory of the point movement reflects the development of the project. The motion of the point Q takes place in $(m+2)$- dimensional project-vector space, $m+1$ whose axes are determined by the categories K_i, $i = \overline{0,m}$, where $(m+1)$ is the number of categories, and $(m+2)$ is the time axis.

Article [18] formulates principles of constructing an applied information technology for planning and administration of technological component of educational environments project-vector management methodology. Functions of projects administration are related to bringing solutions to the executors, ensuring their execution and verification of execution. In project-vector methodology of educational environments managing, management is associated with the choice of correct trajectory of motion, resource support and control of this motion. Administration is the formation of commands to change motion trajectory or the allocation of resources in accordance with the provision of motion on the required trajectory.

In educational environments projects, there are many factors that lead to motion trajectory deviations. These factors include: management decisions, low executive discipline, lack of resources, changes in the organization's strategy, the emergence of a new information, that was not considered in plan, etc. Most of factors requires the intervention of project manager, because they are associated with changes in projects, decision-making. Administration tools are intended for administrative influence on project subjects in case of traffic trajectory deviation from the planned. Trajectory deviation due to reasons: low executive discipline of project subjects, lack of motivation in project subject's activity, low awareness of processes in projects.

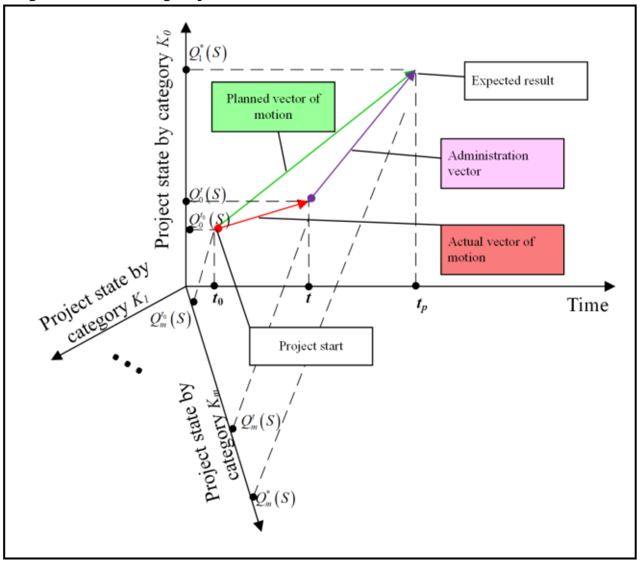

Fig. 1. Finding vectors of administration, planned and actual motion in project-vector space for SEE project

The principle of forming the vector of administration of SEE research project is shown in Fig. 1. This principle is the basis of methodological model for administration tools creating, which also includes direction determination of additional influence on moving subjects in PVS.

Let S be a subject of educational space. We consider its research activities for a period of time T=[t_0, t_p), as one scientific project, where t_0 is moment of time that corresponds to the project start, t_p – the moment of time that corresponds to the project finish (policy term.) Then the planned vector of S-object motion in project-vector space is determined by the formula:

$$\bar{X}(S)=\left(\bar{x}_0(S),\bar{x}_1(S),\ldots,\bar{x}_m(S),\right)=$$

$$=\left(Q_0^*(S)-Q_0^{t_0}(S),Q_1^*(S)-Q_1^{t_0}(S),\ldots,Q_m^*(S)-Q_m^{t_0}(S)\right)$$

where $\bar{X}(S)$ is the planned motion vector of subject s, $\bar{x}_j(S)$ is the value of *j-th* coordinate of planned vector , $j=\overline{0,m}$, *m* number of categories that reflect different aspects of scientific activity, $Q_i^t(S)$ is the results evaluation of *i*-th category of SEE *S* scientific activity for the period of time $[t_0,t)$, $Q_i^*(S)$ is the planned value of *i*-th category results in SEE *S* scientific activity at the time of project finish.

The actual motion and administration vectors are calculated similar to the planned vector using formulas:

$$\tilde{X}^t(S)=\left(\tilde{x}_0^t(S),\tilde{x}_1^t(S),\ldots,\tilde{x}_m^t(S),\right)=$$

$$=\left(Q_0^t(S)-Q_0^{t_0}(S),Q_1^t(S)-Q_1^{t_0}(S),\ldots,Q_m^t(S)-Q_m^{t_0}(S)\right)$$

$$\hat{X}^t(S)=\bar{X}(S)-\tilde{X}^t(S)=$$

$$=\left(\bar{x}_0(S)-\tilde{x}_0^t(S),\bar{x}_1(S)-\tilde{x}_1^t(S),\ldots,\bar{x}_m(S)-\tilde{x}_m^t(S)\right)$$

where $\tilde{X}^t(S)$ is the actual vector of motion of the subject *S* at the time *t*, $\hat{X}^t(S)$ is the administration vector of subject *S* at the time *t*, $\tilde{x}_j^t(S)$ is the actual value of *j*-th indicator of a subject *S* at the time *t*. Administration vector reflects necessary direction of administration tools influence on subjects in project-vector space.

Using the appropriate micro-service of information-analytical system "The base of scientists of Ukraine" [19] as a tool for evaluating the results of SEE scientific activities at any given time, SEE's research administration tool was developed.

Let's consider the functional scheme of infocommunication system, which is a part of toolkit for administering SEE scientific activities: connection with the information-analytical system "The base of scientists of Ukraine" and authorization of user is carried out; there is SEE search in the system (found identifier is fixed and used later in queries formation); administrator determines project start t_0, policy term t_p, and the planned values of the SEE *S* scientific performance evaluations at the time of project finish for each of the categories $Q_i^*(S)$; a request is sent to the micro-service of the information-analytical system to calculate SEE *S* activity results at the initial moment of time; based on the response of the micro-service, the vector of the planned motion is calculated; during the project implementation, with a certain periodicity to micro-service of information-analytical system, calculates the results of SEE *S* activity at the current time; based on the response of the micro-service, the vectors of the actual movement and the vector of administration are calculated; on the basis of administration vector, the impact on the project through the redistribution of resources, and the use of other management tools, which are described in more detail in [19] is carried out.

The basis of information-analytical system "The base of scholars of Ukraine" interaction and infocommunication system for SEE scientific activities administration is an API micro-service evaluation of scientific activity results. Interaction is carried out by exchanging POST requests through the HTTPS protocol.

Request for an assessment of SEE scientific activity results should contain the following parameters:

- *Task* which should be equal to "EVALUATE";
- *id* is digital SEE identifier in "The base of scientists of Ukraine" system,
- *Start_time* is the start point of time from which it is nessesary to evaluate SEE scientific activity results;
- *Finish_time* is the end point of time for which it is necessary to evaluate SEE scientific activity results;
- *Details* is the boolean parameter, that defines whether or not to provide a detailed response.

For successful request execution, the system must contain information about specified SEE. Searching for the SEE identifier occurs before the request is generated. It can be implemented using the appropriate API's of the system or manually using the web interface.

In response to a request, the micro-service sends a report on the SEE scientific activities results evaluation for the specified period. The report is an object in the JSON format. If the *Detail* parameter of request was False, the answer contains a single field: *Marks* is an array of SEE scientific activity results evaluations. Each element of an array is a pair of category identifier and numeric value.

If the *Detail* parameter of request was True then the answer also contains the following fields:

- *Categories* is the list of categories K_i, $i=\overline{0,m}$, which evaluates SEE activity. Each category contains the following fields: *id* is the numeric category identifier; Name is the category name; Description is the category description; Index is an array containing a list of indicators $\Pi_0,\Pi_1,\ldots,\Pi_{k_i}$ belonging to relevant category K_i.
- *Values* is an array containing arrays for each category indicators. Each element of array is an identifier pair and numeric value of indicator. Structure of indicators values corresponds to Categories' structure.

On the basis of received information, the system is building an administration vector. This vector can be used by the person who makes decisions for management tasks. It can also be considered as an input parameter for automated control systems, which solve the problem of PVS project movement trajectory optimization.

CONCLUSIONS

Let's illustrate the example of the concept used in the article. Developed system was tested at the Department of System Analysis and Optimization Theory in "Uzhhorod National University". The main purpose of project is to conduct research on the topic "Models and Methods of

Optimization" №36A-2015. An application of system made it possible to compute administration vectors for the department as a whole and for each employee separately. The use of these vectors enabled Head of department to formulate individual plans for 2017-2018 academic year, taking into account recommendations and to improve the scientific and metric parameters of department.

TABLE I. THE COMPARISON OF SCIENCE-ECONOMIC INDICATORS OF SAOT DEPARTMENT.

No.	Indicator	Value		
		I semester 2017	*I semester 2018*	*Relative gain*
1	Number of scientific and pedagogical workers rates	9,25	8	-13,5
2	Number of publications in professional editions	23	21	-8,7
3	Number of materials in all-Ukrainian and international conferences	16	26	62,5
4	Number of publications, indexed in SCOPUS international science and technology base	4	5	25
5.	H-Index in SCOPUS International Science Center	2	4	50

There is the introduction of scientific research system in mathematical faculty of the State University "Uzhhorod National University".

In the article the method of calculation of motion vectors and administrative influence in the PVS is developed, as well as created an infocommunication system for scientific activity administration, which is an integral part of SEE's administration tool. Developed system is integrated with the micro-services of the information-analytical system "The base of scientists of Ukraine", which makes it possible to use an up-to-date database containing information about publications of Ukrainian scholars. This system helps heads of HEI units to simplify management, reallocate resources between different aspects of relevant unit activity.

It is planned to implement the system at other universities in Ukraine in the future. The research of the managerial effect of the implementation of the system is continued. Also it is planned to use the results of project-vector methodology to develop a decision support system for scientific research management.

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