Пропонується прикладна інформаційна технологія планування та адміністрування технологічного компонента методології проектно-векторного управління освітніми середовищами. Запропоновано комбінований метод планування інформаційно-продуктових проектів, який включає розрахунок термінів виконання робіт без урахування розподілу ресурсів та імітаційне моделювання розподілу ресурсів між роботами. Запропоновано метод розрахунку векторів адміністрування, які відображають рух проектів в проектно-векторному просторі. Розглянуто засоби для компенсування впливу непередбачуваних ситуацій на реалізацію проектів суб'єктів освітніх середовищ

Ключові слова: освітнє середовище, проектно-векторне управління, проектно-векторний простір, вектор адміністрування

Предлагается прикладная информационная технология планирования и администрирования технологического компонента методологии проектно-векторного управления образовательными средами. Предложен комбинированный метод планирования информационно-продуктовых проектов, включающий расчет сроков выполнения работ без учета распределения ресурсов и имитационное моделирование распределения ресурсов между работами. Предложен метод расчета векторов администрирования, отражающих движение проектов в проектно-векторном пространстве. Рассмотрены средства для компенсации влияния непредвиденных ситуаций на реализацию проектов субъектов образовательных сред

Ключевые слова: образовательная среда, проектно-векторное управление, проектно-векторное пространство, вектор администрирования

UDC 005:37

DOI: 10.15587/1729-4061.2018.126301

DEVELOPMENT OF TECHNICAL COMPONENT OF THE METHODOLOGY FOR PROJECT-VECTOR MANAGEMENT OF EDUCATIONAL ENVIRONMENTS

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1. Introduction

Applied information technologies for planning, administration, and assessment of research activities include databases containing outcomes of activity, methods of data actualization and methods of processing for the purpose of constructing vectors and calculation of comprehensive scores. In addition to the calculation of comprehensive scores and vectors of scientific research activity administration, methods for the prediction of scores for planning effective activity of subjects of educational environments are considered. The subjects of educational environments (SEE) are scientists, higher educational institutions, and structural subdivisions: institutes, faculties, departments, groups of scientists, united by involvement in a specific project, etc. It is known that most methods for assessment and planning SEE activity are characterized by the fact that they do not take into account complete information, require solving additional problems (carrying out expert assessment, selection and adjustment of parameters, etc.). Information on SEE performance is often unstructured, incomplete, obtained from different sources. The application of known methods of assessment, planning, and administration of SEE activity is limited under these conditions. Promising directions in the development of information technologies for SEE performance assessment is the construction of comprehensive scores that take into account different aspects of activity, minimize the impact of a subjective factor on calculation of scores. The use of project-vector models for planning and administration of directions of scientific research is also promising. The first problem has been preliminary solved [1–5], while the second one requires a separate exploration, specifically, in the part of representation of SEE activities as a set of projects of different levels of complexity, different terms of completion and different resource needs.

Resolving contradictions between the requirements for planning the strategies for management of higher educational institutions and tasks of scientifically reasonable performance assessment is possible by the construction of information technology for the evaluation of scientific research projects based on a project-vector paradigm. Known methods of planning, administration, and assessment of scientific and research activities at higher educational institutions do not make it possible to reflect activity outcomes fully and maximally objectively, which leads to making insufficiently effective management decisions. Imperfect tools for solving major problems of the project-vector methodology in the part of evaluation and planning activities of subjects of educational environments deter development of the theoretical and practical base in this direction. Given this, the study, which is aimed at the creation of applied information technologies for the employment of methodology for project-vector management related to the problem of administration, planning and performance assessment of SEE, is important.

2. Literature analysis and problem statement

Methodology of project-vector management of educational environments considers the principles of time, resources and change management, which is an integral part of effective SEE activity. In paper [1], fundamental principles of combined use of the methodology of project-vector management of educational environments and methodologies of SEE performance assessment are explored. Paper [2–5] considers the methods of SEE performance assessment. Specifically, paper [2] contains formulas for the calculation of vector and scalar scores of research and scientific performance of scientists. These methods are considered in terms of application to activities of scholars only, but can be used for assessment and planning of activity of other SEE. Paper [3] describes the method of transition from qualitative to quantitative scores, which requires involvement of experts. It is a separate task that is difficult to implement. Article [4] explores the method of planning and prediction of development of scientific research directions based on sliding averages. The models of sliding averages are considered as it is believed that development of scientific directions has a forwarded character. However, a scientific direction is difficult to represent by a scalar score and its development must be considered in integrity, taking into account various aspects of subjects' activity. In paper [5], the problem of identification of scientific research directions of scientists is solved by means of cluster analysis of scientific publications. The methods that are described in [5] can be used as a foundation for conducting subsequent prediction of the development of scientific directions and development of effective methods of financial and motivational management, etc. In order to predict and evaluate quality of higher educational institution's performance, the parametric model and the structure of processes of an educational institution as SEE was developed in paper [6]. Parameters of the influence of processes on each other, which is an important component of project management of educational environments in general, were analyzed in paper [6].

The developed tools for SEE performance assessment should be considered in dynamics, in an inseparable connection with the projects, implemented by SEE. Depending on the SEE under consideration, each SEE project as a management object has its own characteristics. Papers [7, 8] considered the models of interaction between education support projects and the problems of implementation of international standards of evaluation of competencies of projects and programs managers. The models, described in papers [7, 8], focus only on educational projects, which in general does not limit application of evaluation of competencies for other projects, implemented by SEE. Article [9] considered probabilistic transitions of Markov chains for project environment, which determine the characteristics of a project. Moreover, these characteristics transit step by step from one state to another with certain probabilities. The structure of communication between the main subjects of the educational environment and implementation of the Markov chain for projects' environment as SEE objects can be used for forming the vector of SEE project administration. In paper [10], the features of application of Markov chains to formation of the lifecycle of scientific publications were explored.

Paper [11] outlined the ways of integration of project management and decision making support by using a matrix model based on the key portfolio events. The features of application of a matrix model in paper [11] can be adapted to project-vector management of educational environments. Article [12] describes the integration of information systems of higher educational institutions into a unified ecosystem, in which management can be based on a matrix model with consideration of the project-vector principles. In [13], it is shown that for solving time-, budget- and expectations-related problems of a project, specifically in the field of education, it is necessary to form organizational culture. This organizational culture has a tendency to joint usage, cooperation and extension of possibilities for project implementation.

Paper [14] examines the ideological concepts of management with special attention given to management of higher education itself. The principles of the new management, which are described in [14], can be the basis for the reform in higher education, which is in line with the concept of project-vector management of educational environments. Article [15] describes the project management-based principles of learning. Detailing the concept of project management in technical education is described in [16]. Research [17] described the approach to the management of educational process based of the problem analysis and the Danish model of project-based learning. In general, all the described concepts are a search for new ways of solving the task of improving management efficiency of some SEE. However, these concepts do not propose a universal approach to the management of an educational environment in general.

In article [18], it is emphasized that the systems of innovative approach are useful for better understanding of innovative processes, as well as for knowledge production and distribution in the economy. The work provides conceptual and theoretical foundations for further study of innovations in the systems context, which can be used for implementation of the project-vector management of educational environments as an innovative process. One of the innovative dimensions in this respect is representation of SEE activity as a set of projects of different levels of complexity, different terms of implementation and needs for resources. This activity can be implemented in the form of a system consisting of micro-services. The principles of distributed management system, the principles of interaction micro-services in this system, etc. are presented in paper [19]. The described information system can be used for practical implementation of the processes of project-vector management of educational environments, specifically for creation of the applied information technology planning and administration of SEE activity.

The study, which is aimed at the creation of tools for administration and planning of the technological component of the methodology of project-vector management of educational environments will make it possible to create an information technology, which would provide mechanisms for SEE activity management.

3. The aim and objectives of the study

The aim of present research is to create the applied information technology, which would implement the mechanisms for management of educational environments based on a project-vector methodology. This will make it possible to create the appropriate micro-services of information-analytical system for project management of education environments, including determining resources and coordinates of project administration vectors.

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

– to create tools for planning of the technological component of the methodology of project-vector management of educational environments;

– to create tools of administration of the technological component of the methodology of project-vector management of educational environments;

– to explore the impact of technical problems on projects in terms of projects administration of subjects of educational environment subjects.

4. Structure of the technological component of the methodology of project-vector management

Technology of project-vector management of projects of educational environments is focused on improving efficiency of the processes of formation of information resource of project management systems of educational environments. Scientific-methodological tools of formation of the technological component make it possible to increase efficiency of management of projects of educational environments.

Let us consider the technological component and problem management component in the methodology of project-vector management of educational environments. These components will be considered in terms of linking the methods and ways that exist in project management to the specifics of management of educational environments.

The technological component of the methodology of project-vector management of educational environments contains an integrated technological system of scientifically-methodical (models and methods) and practical (business processes, procedures, ways) of the tools for formation of information project management systems. All the methods and ways are based on the models of project development, which correspond to motion of some essences in the project-vector space and aimed at obtaining information by a decision maker. These methods and models are a part of the technology of project-vector project management of educational environments.

It is proposed to use the tools of planning, administration, product formation and support in the structure of the technological component of the methodology of project-vector management of educational environments. The tools are formed based on the specifics of activity of organizations in educational environments, as well as on the structure of the project-vector space and objects.

Methodology of creation of tools of project management of educational environments includes a set of models and methods that enable construction of sequences of actions on creation of information resource for a decision maker. The tools, specific for a given subject area (objects of the project-vector space (PVS) and developed ways of using these tools (trajectories of motion in the project-vector space) will be displayed in the methodology.

Consider in detail the tools of the technological component of the methodology of project-vector management of educational environments that can be used for creation of the applied information technology of planning and administration of SEE activity.

Planning tools enable not only calculation of the optimal motion trajectory, but also the optimum distribution of resources among objects and subjects of the PVS. Activity of educational institutions is characterized by the fact that many tasks can be solved by many executors. Since most projects are information-productive, both equipment and executors can be different. Almost always there is a significant set of resources, from which a specific set of resources for a specific task is selected. Different material resources, equipment, etc. can be used. That is why the task of planning, on the one hand, is simplified (there is almost never a lack of resource), on the other hand, is complicated because it also requires a solution of the problem of optimization of choosing specific resource for a particular task.

Administration tools are based on implementation of planning tools. In addition to a plan, it is required to use high-quality tools of information interaction of PVS subjects, because administration focuses on bringing tasks to executors, performance management and reporting system.

Tools of project products formation. Technological processes of project products formation are not related to the methodology of project management, but the project-vector methodology of management of educational environment takes into account the specificity of information-product projects. More precisely, if there is a technology of formation of information products of projects, it is almost always possible to separate a part of it, which can be imagined as a project. It is this part of the technology of formation of project products that will be displayed in the methodology of project- vector management of educational environments.

Tools of support of project management processes. They include the following tools: financial provision (budgeting), provision with material resources, provision with labor resources, scientific-methodical support, and information support. They correspond to the processes, implemented in enterprise management. That is why implementation of this component of the technology can be based on ERP (Enterprise Resource Planning) system.

Consider implementation of the technological component of the methodology of the project-vector management of educational environments.

5. Tools for planning technological component of methodology of project-vector management of educational environments

A project plan within the methodology of project-vector management of educational environments includes trajectories of motion of PVS objects and subjects from the starting point (beginning of a project) to the target point (all or almost all of project outcomes obtained). Calculation of the optimal trajectory of motion in PVS involves coordination of motion of PVS objects and subjects due to the optimum distribution of allocated resources for works, purchases, etc. Basic documents for this are:

1. Order on project initiation that determines directive parameters of its implementation.
2. Description of the project's content.
3. List and description of available material and technical resources and equipment.
4. Estimated labor productivity and structure of labor resources.
5. Price lists.

The project plan that reflects the optimal trajectory of motion of PVS objects and subjects is developed with the use of selected planning tools. The plan shall be approved by the project team, based on the planned volume of work, resource requirements and cost of resources, executors, mechanisms, and terms of purchases taking into account the allocated funding. The common project planning instruments can include: the critical path method, the PERT method (Program (Project) Evaluation and Review Technique) the method of critical circuits, simulation, and probabilistic methods, etc.

The mentioned project planning methods and ways are effective in management of the terms of projects of educational environments, with the exception of works of information product projects, which are not managed but administered by managers. For example, they get permission from the government bodies to perform a certain action. But these tools cannot be used for planning and management of project resources. Let us assume that

$$R=\left\{r_j \,\middle|\, j=\overline{1,N_R}\right\}$$

is the set of project works, N_R is the number of works. In this case, a fixed work r_k, $k\in\{1,2,\ldots,N_R\}$ is determined as a tuple:

$$r_k=\left\langle a^k,d^k,U^k,s^k,w^k\right\rangle,$$

where a^k is the name of work r_k, d^k is the duration of work r_k, U^k is the set of resources, required to execute work r_k, s^k is the relation of work r_k, w^k is the address of work r_k in the structure of project works.

If $U=\left\{u_i \,\middle|\, i\in I_U\right\}$, where $I_U=\{1,2,\ldots,n_U\}$, n_U is the number of all project resources, each resource u_i is described by tuple:

$$u_i=\left\langle b^i,e^i,z^i,O^i,\omega^i\right\rangle,$$

where b^i is the name of resource u_i, e^i is the units of measurements of resource u_i, z^i is the resource costs u_i, O^i is the resource reserve u_i, ω^i is the content of resource u_i.

The set of resources for work r_k is formed from the set of all project resources. Let U be the set of all project resources, then $U^k\subseteq U$:

$$U^k=\left\{u_i^k \,\middle|\, k\in\{1,2,\ldots,N_R\}, i\in I_k, I_k\subseteq I_U\right\}, \quad (1)$$

where u_i^k is the separate resource of the i-th kind for work r_k, n_k is the amount of resources, necessary to perform work r_k, I_k is the set of indices of resources, which are necessary to perform work r_k.

In the process of project preparation, the listed parameters of project works are determined. After that, the schedule is calculated so that the amount of resources consumption during execution of a project should not exceed limitations:

$$\forall u_i\in U,\;\; t_{\min}\le t\le t_{\max},\;\; o^i(t)\le O^i(t), \quad (2)$$

where $t_{\min}$ is the moment of project start, $t_{\max}$ is the moment of project completion, $o^i(t)$ is the need for resource u_i at moment t, $O^i(t)$ are the available resource reserves u_i at moment t.

The specifics of projects in educational environments is that a lot of resources of one kind are allocated for performing works, for example, the time that scientists spend on execution of projects. In the problem of project management for two assigned works r_{k_1} and r_{k_2}, that $I_{k_1}\subseteq I_U$ and $I_{k_2}\subseteq I_U$ we obtain that $I_{k_1}\cap I_{k_2}=\varnothing$. In problems of management of SEE projects and activity, specifically of higher educational institutions, there can be the case that $I_{k_1}\cap I_{k_2}\ne\varnothing$. For example, there is a set of scientists who carry out certain research and there is a set of scientific projects. Each scientist can be involved in many projects. Thus, the problem of selection of project executors is added to the planning problem, taking into account the limitations in (2). The combined method for planning the projects of educational environments, which stage by stage solves the problem of planning and resource allocation, is proposed (Fig. 1).

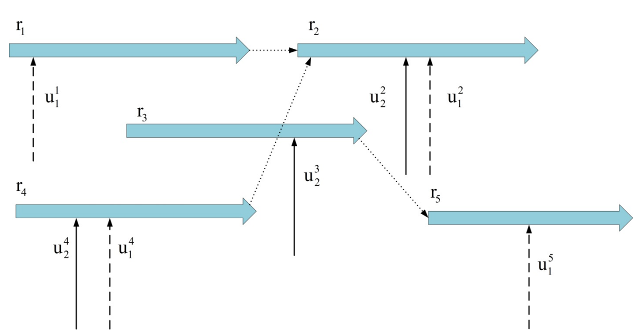

Fig. 1. Scheme of the combined problem of planning with resources allocation to works of a project in applied information technology of planning and administration of SEE activity

Resources in the projects of educational environments could include specialists in subdivisions of organizations of educational environments, teachers, classroom, equipment, materials, etc. In the system, which is designed for verification of the proposed methodology, the first type of resources was used: researchers who work in organizations of educational environments, higher educational institutions, and subdivisions of educational institutions.

The combined method for planning information-product projects. The approach is based on the intersection of two groups of processes. The first is construction of the technological sequence of works, unlike the classical critical path method that takes into account resource limitations. The second is allocation of one type of resources to different works of a project. Calendar-network planning is used in the first part of the method. Imitation planning, based on the search for better variants of resource allocation, is used in the second part. The second part is based on the Monte Carlo method. The difference from the critical path method lies in the fact that the combined method of planning information product projects, in addition to time reserves for completion, takes into consideration restrictions on other types of resources, such as available funds, employment of executors in other projects, etc.

The combined method of planning of information product projects is implemented under the following scheme:

1. Calculation of the early and late terms of works execution without regard to allocation of resources.

2. Random allocation of a necessary type of resource to work. That is, one resource is selected from each type of resources and allocated for all kinds of work that require exactly this kind of resources. Probability of choosing a resource of each kind is calculated from the formulas:

$$\forall\rho_i^k>0,\rho_j^k>0,\quad p_i^k=\frac{\rho_i^k}{\sum_j\rho_j^k},\ \text{if}\ \exists\rho_j^k>0, \tag{3}$$

$$\forall\rho_i^k<0,\rho_j^k<0,\quad p_i^k=\frac{\sum_j\rho_j^k-\rho_i^k}{\sum_j\rho_j^k},\ \text{if}\ \forall\rho_j^k<0, \tag{4}$$

$$p_i^k=\frac{1}{2},\ \text{if}\ \forall\rho_i^k=0, \tag{5}$$

where ρ_i^k is the priority of resource u_i^k, $u_i^k\in U^k$, $U^k\subseteq U$, p_i^k is the probability of selection of resource u_i^k.

3. Calculation of resources loading. If there is no resource conflict, complete planning. Proceed to point 9.

4. Selection of additional resource of the type, to which the resource that does not meet the restrictions belongs. Possibility of selection is calculated from the formulas (3)–(5). If there is such resource, the old resource is replaced with the selected resource in one of the works. If there is no such resource, proceed to point 7. Memorizing the selected resource. Selection of work, in which the resource is replaced, is carried out according to probability, which is calculated from the formulas:

$$\forall\tilde\rho_i^k>0,\tilde\rho_j^k>0,\quad \tilde p_i^k=\frac{\tilde\rho_i^k}{\sum_j\tilde\rho_j^k},\ \text{if}\ \exists\tilde\rho_j^k>0, \tag{6}$$

$$\forall\tilde\rho_i^k<0,\tilde\rho_j^k<0,\quad \tilde p_i^k=\frac{\sum_j\tilde\rho_j^k-\tilde\rho_i^k}{\sum_j\tilde\rho_j^k},\ \text{if}\ \forall\tilde\rho_j^k<0, \tag{7}$$

$$\tilde p_i^k=\frac{1}{2},\ \text{if}\ \forall\tilde\rho_i^k=0, \tag{8}$$

where $\tilde\rho_i^k$ is the priority of work r_k, $\tilde p_i^k$ is the probability of selection of work r_k.

Memorizing the selected work.

5. Calculation of resources loading. If a resource conflict is eliminated, proceed to p. 9.

6. If there are time segments, on which the first resource does not satisfy the restrictions, and total loading of the first and the new resource satisfies restrictions, the first resource is replaced with the new one at works that are performed during this period. If a resource conflict is eliminated, planning is completed. Otherwise, proceed to point 4.

7. Selection of resource that does not meet restrictions. Probability of selection of a resource is calculated from the formula (3)–(5). The shift in time of works creates a resource conflict.

8. If a resource conflict is not eliminated, proceed to point 7.

9. Change in terms of project completion and characteristics of resources distribution in the overall evaluation of the calculated plan of works can be carried out by different methods: expert, probabilistic, heuristic, etc.

Assessment of the variants of the plan, obtained when choosing a resource/work is based on "memorizing" resources and works, selected in the process of calculation of the next variant of the plan. Increment in the score can be carried out based on satisfaction/dissatisfaction of the calculated plan, or from formal criteria – the project duration or distribution of its value in time.

10. If the result is not satisfying, continue the search for a better option, beginning from point 2.

6. Tools for the administration of a technological component of the methodology of project-vector management of educational environments

Administration functions in projects are related to bringing solutions to executors, ensuring their implementation and control of their fulfillment. In the methodology of the project-vector management of educational environments, this management is related to selection of the correct trajectory of motion, resource provision and motion management. Administration involves formation of orders to change the motion trajectory or resources allocation in accordance with ensuring moving by the necessary trajectory. In projects of educational environments, there are many factors that lead to deviation of the motion trajectory. These factors include decisions of authorities, low executive discipline, lack of resources, a change in the strategy of the organization activity, emergence of a new strategy, not accounted in information planning, etc. Most factors require intervention of a project manager because they are associated with changes in projects and decision making. The administration tools are intended for administrative influence on the project subjects in case of deviation of the motion trajectory from the one that was planned. Deviation of the trajectory may be caused by the reasons, such as low executive discipline of project subjects, insufficient motivation of activity of subjects of projects, low awareness about project processes.

For effective administration, it is necessary to formalize the process of influence on subjects of projects at deviations from the planned trajectory of the whole path of motion from the starting point to the target point (Fig. 2).

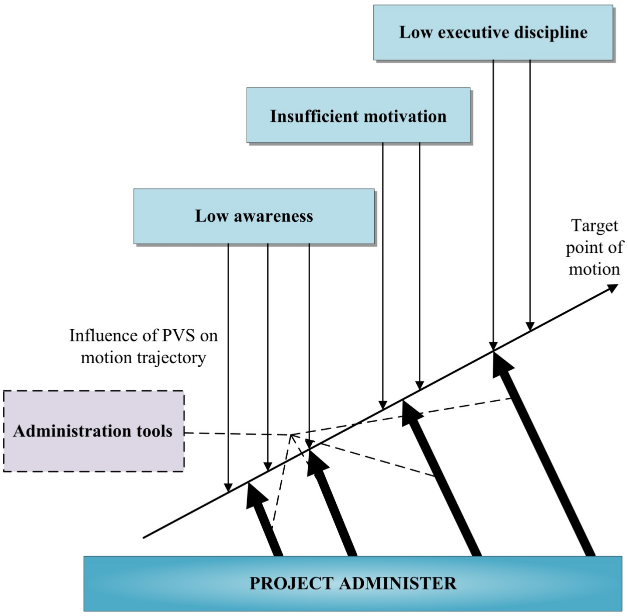

Fig. 2. Role of administrator of projects of educational environments of applied information technology of planning and administration of SEE activity

Fig. 3 shows the principle of formation of the vector of administration of projects of educational environment of the project-vector space. This principle is the basis of the methodological model of creation of administration tools, which also includes determining of the direction of additional impact on object and subjects, moving in the project-vector space.

Let us assume that Π_1, Π_2,..., Π_z are some projects of educational environments of the project-vector space, $Q_1^k, Q_2^k, \ldots, Q_{h_k}^k$ are the objects or subjects of a certain project Π_k, $k=\overline{1,z}$, z is the number of projects, h_k is the number of objects or subjects of project Π_k. Then the planned vector of motion of object or subject Q_i^k of project Π_k in the project-vector space at $i \in \{1,2,\ldots,h_k\}$ is determined from formula:

$$\hat{A}_i^k(t) = \left[\hat{x}_{i_1}^k(t), \hat{x}_{i_2}^k(t), \ldots, \hat{x}_{i_p}^k(t)\right],$$

where $A_i^k(t)$ is the planned vector of motion of object or subject Q_i^k of project Π_k at moment t, p is the number of components, which determine the motion vector, $\hat{x}_{i_j}^k(t)$ is the planned value of the j-th indicator of the i-th object or subject Q_i^k of a project Π_k at moment t.

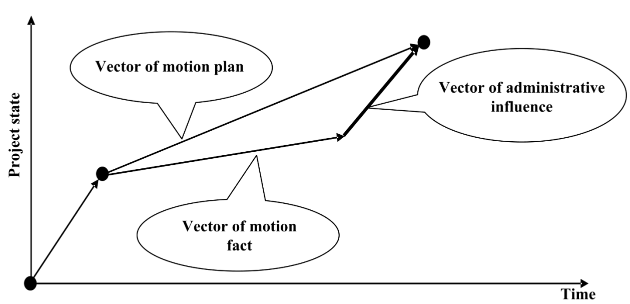

Fig. 3. Formation of vector of administration of projects of educational environments in applied information technology of planning and administration of SEE activity

Similar to the planned vector, we find the actual motion vector and administration vector from the formulas:

$$\tilde{A}_i^k(t) = \left[\tilde{x}_{i_1}^k(t), \tilde{x}_{i_2}^k(t), \ldots, \tilde{x}_{i_p}^k(t)\right],$$

$$A_i^k(t) = \hat{A}_i^k(t) - \tilde{A}_i^k(t) =$$
$$= \left[\hat{x}_{i_1}^k(t) - \tilde{x}_{i_1}^k(t), \hat{x}_{i_2}^k(t) - \tilde{x}_{i_2}^k(t), \ldots, \hat{x}_{i_p}^k(t) - \tilde{x}_{i_p}^k(t)\right],$$

where $\tilde{A}_i^k(t)$ is the actual vector of motion of object or subject Q_i^k of project Π_k at moment t, $A_i^k(t)$ is the vector of administration of object or subject Q_i^k of project Π_k at moment t, $\tilde{x}_{i_j}^k(t)$ is the actual value of the j-th indicator of the i-th object or subject Q_i^k of a project Π_k at moment t.

It is also possible to find the metrics, some of which described in [2], in order to find administration vectors. An administration vector reflects the required direction of impact of administration tools on PVS objects or subjects. Consider the administrative tools that are used for projects of educational environments, which can be implemented in applied information technology of planning and administrating SEE activity.

Professional administrating is based on the planning technology with the use of high-quality tools of information interaction of PVS subjects. This tool may be specialized administration systems and technologies, functioning in accordance with the following rules.

Rule 1. A plan is the basis for project management in educational environments. Any project task is formed from the plan.

Rule 2. All tasks must be in a written form and preferably be formed automatically from the planning system by the scheme:

1) a person in charge and executors are indicated for each project work;

2) a planning period (a day, a week, a month) is determined. A week suits best the projects of educational environments;

3) the works, performed within a planned period, are determined from the plan. Critical works are of top priority;

4) the E-mail messages about the works to be performed (or completed) within the planned period are sent automatically to people in charge and to executors;

5) messages about support of project works (material and technical resources, finance, documents, orders, directions, procedures, etc.) are automatically sent to project support services with obligatory indication of the timing of provision of these resources.

Rule 3. Tasks completion should be fixed and confirmed by people in charge in the planning system. This should be implemented according to the following scheme:

1) an executor indicates the facts of task completion in electronic form during performance of work within a planned period. If the work was not fully completed within this period, an executor indicates to what extent it was fulfilled by the end of the period (as percentage of completion, calculated by labor consumption, or a required additional time to do the work);

2) at the end of the period, a person in charge confirms or rejects the specified extent of work, completed by a executor;

3) at the end of the period, after confirmation of the fact that the work was done by a person in charge, the project manager confirms or does not confirm the information of people in charge;

4) a message about completion of implementation of the plan of works for the period is automatically sent to the curator, the manager, and the administrator of the project. Based on this information, the project manager makes a decision about correction of the project plan (if necessary), and the project administrator (if necessary) launches additional tools of the project administration. In the first place, they are motivational.

The information is at the base of management of any processes and projects. Lack of information or its low quality leads to occurrence of many uncertainties in terms of motion in the project-vector space. Insufficient, inaccurate information does not make it possible to determine objectives of subjects in projects, does not enable accurate calculation of the optimal motion trajectory and is the source of the many risks and changes.

It is possible to eliminate this shortage in two ways. The first way is to increase the level of awareness. It is difficult to implement because a significant part of information refers to the unmanageable part of a project. In addition, it most often requires considerable financial costs, which is difficult to provide. The second way is to apply models and methods, created for project management under conditions of uncertainty. It is possible to ensure achievement of target points of motion when project administration is effective. First of all, administration, which compensates for the lack of information at early stages of projects of educational environments, allows achievement of the project goals due to changes. That is why it is very important to display procedure of changes management in projects of educational environments in the methodology of the project-vector management. This methodology is based on displaying all changes in projects' environment as "an expansion of the Universe of projects". Achievement of project objectives is represented by the motion in the project-vector space. The scheme of formation and adjustment of the plan of projects of educational environments, connected with arrival of new information, is shown in Fig. 4.

Changes in the plan of projects of educational environments (trajectories of motion of SEE objects and subjects) are the result of:

1. The influence of external factors.
2. Poor work of executors.
3. A result of the influence of risky events (change in standards and norms, failure of technique, admission of students, change in management policy, etc.).
4. A poor project plan, which in turn is a result of poor awareness or unprofessionalism or those who are planning a project.

In the course of the study it was found that the scheme of formation of the plan of projects of educational environments (form bottom to top), which was developed in the framework of the project management methodology, is not applied in Ukraine. Fuzzy problem statement (for information-product projects), a considerable amount of work with documentation, the absence of all documentation during planning, the variability of behavior of executors, unstable financial and economic conditions of activity lead to the situation when it is impossible to form an actual plan. An actual plan is often formed already in the course of work. That is why the formation of an actual plan can and should be based on expert assessments of executors. Thus, in the part of formation of a project plan, the role and importance of administrative procedures in the methodology of project-vector management of educational environments becomes decisive.

Under conditions of projects of educational environments, a project plan must be corrected constantly in order to display the changes that occur and new information. The purpose of amendments to the plan is to keep it up-to-date. Any deviation from the plan should be fixed by both the project executors and employees of those functional services that directly contact with executors. If it is necessary to make constant changes, it means that it is required to create such a system of administration of projects of educational environments that can be flexibly readjusted in the process of interaction with dynamic surroundings.

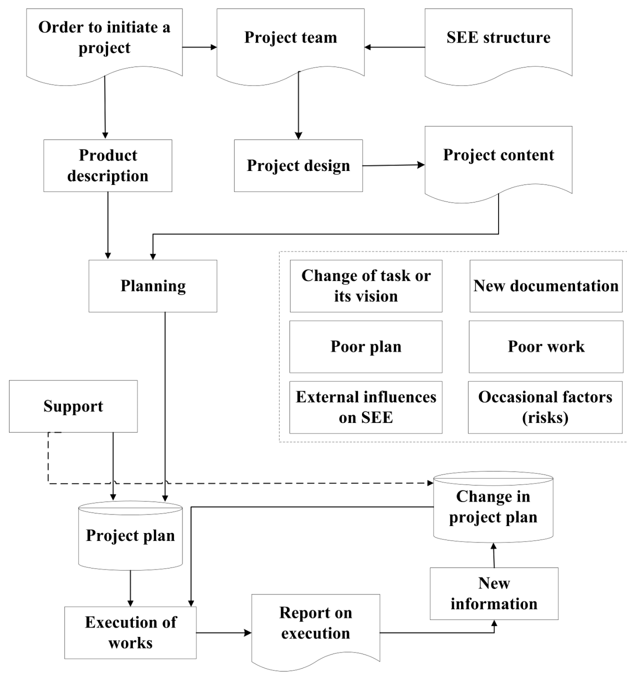

Fig. 4. Scheme of formation and adjustment of the plan of projects of educational environments, connected with arrival of new information in applied information technology of planning and administration of SEE activity

That is why the conception of displaying new information in project plans was developed in the framework of the methodology of project-vector management of educational environments. This conception is based on the plan adjustment to the formed conditions of project implementation, which is performed according to the following rules:

Rule 1. Changes are added to the plan supplement "Changes of the project plan".

Rule 2. Links to the elements of "Changes of the project plan", represented in the form of some virtual resources, are fixed in the project plans.

Based on this concept, the scheme of management of changes in the project plan was designed (Fig. 4). In case of management of changes according to this scheme, new information is identified and "Changes in the project plan" are formed. Some circumstances that were not foreseen during creation of a project plan arise during execution of works, the procedure of management of changes in the project plan comes in force.

In the classic statement, in each project management system, it is possible to separate functional subsystems, the activity of which is focused on project management and ensuring the potential of such management. It is proposed to separate the following sub-systems in the methodology of the project-vector management of educational environments:

– ensuring the availability of labor resources, ensuring the availability of material resources;

– financial support;

– information support;

– scientific and methodical support.

Among the listed four subsystems, the first four are traditional and implemented by correspondent subdivisions of organizations of educational environments. The source of financial, material-technical, informational support and provision with labor resources is the information, obtained in the process of project planning. That is why the main task of the scientific-methodical subdivision is to develop and implement the technology and methodology of project planning, taking into account implementation of subsystems.

The theoretical base of support subsystems includes methods and models of construction of the project-vector space and finding better ways of motion in this space for all objects and subjects of educational environments, involved in projects. Provision subsystems play the role of energy that is used for motion in PVS. The more and the better support, the easier it is for objects and subjects of a project to move in the project-vector space. And whereas project problems prevent the motion, support subsystems facilitate this motion.

Technical problems in projects in interpretation of the methodology of the project-vector management are the obstacle to the motion in the right direction, which is associated with accidental events, uncertainties, and changes. Technical problems in projects are additional resistance in direction to target points. This resistance can lead to the fact that:

– target points will never be reached;

 it is necessary to change the motion trajectory (project plans);

– additional energy (resources) is needed to overcome this resistance;

– time will be lost and outcomes (target points) will be reached later.

The model of goal-setting in PVS can be used to adjust the motion trajectory in case additional resistance should occur. Let us assume N_1, N_2,..., N_c are directions of motion. Then resistance to motion is calculated from formula:

$$F_j^{ik} = \gamma_j^{ik} \cdot \left(V_j^{ik}\right)^2,$$

where F_j^{ik} is the resistance of motion of PVS subject or object Q_i^k of project Π_k in the direction of motion N_j, $k=\overline{1,z}$, $j=\overline{1,c}$, γ_j^{ik} is the coefficient of resistance of motion of PVS subject or object Q_i^k of project Π_k in direction of motion N_j, V_j^{ik} is the speed of motion of PVS subject or object Q_i^k of project Π_k in direction of motion N_j.

The needs for energy or resources for the motion toward direction Nj are determined as follows:

$$e_j^{ik} = F_j^{ik} \cdot S,$$

where e_j^{ik} is resources, required for counteraction to resistance of motion of PVS subject or object Q_i^k of project Π_k in direction of motion N_j, S is the path of PVS subject or object.

Project problems are characterized by an increase in coefficient of resistance to motion γ_j^{ik}. Let $\overline{\gamma}_j^{ik} > \gamma_j^{ik}$, where $\overline{\gamma}_j^{ik}$ is the coefficient of resistance to motion of PVS subject or object Q_i^k of project Π_k in direction of motion N_j, that takes into consideration technical problems of the project. Then

$$\overline{F}_j^{ik} > F_j^{ik} \text{ or } \overline{\gamma}_j^{ik} \cdot \left(V_j^{ik}\right)^2 > \gamma_j^{ik} \cdot \left(V_j^{ik}\right)^2,$$

where $\overline{F}_j^{ik}$ is the resistance to motion of PVS subject or object Q_i^k of project Π_k in the direction of motion N_j taking into consideration technical problems of a project. That is, if unforeseen situations should occur, resistance to motion increases. Let

$$\overline{F}_j^{ik} = \overline{\gamma}_j^{ik} \cdot \left(\overline{V}_j^{ik}\right)^2,$$

where the speed of motion of PVS subject or object Q_i^k of project Π_k in the direction of motion N_j, taking into consideration costs for resistance. Then, in for $\overline{F}_j^{ik} = F_j^{ik}$, it is necessary that speed should be $\overline{V}_j^{ik} < V_j^{ik}$. That is, time for completion under conditions of additional resistance, caused by problems in a project, increases.

Three methods to solve the problem are:

1. To create the reserve of resources to overcome the areas of space, in which resistance occurs. In order to preserve the speed of motion, additional energy e_j^{ik}. is required. From the fact that $\overline{F}_j^{ik} > F_j^{ik}$ we obtain that $\overline{e}_j^{ik} > e_j^{ik}$, i. e. $\overline{F}_j^{ik} \cdot S > F_j^{ik} \cdot S$, where $\overline{e}_j^{ik}$ is resources, required for counteraction to resistance to motion of PVS subject or object Q_i^k of project Π_k in the direction of motion N_j taking into consideration additional resistance. Additional energy or resources are determined as:

$$de_j^{ik} = \overline{e}_j^{ik} - e_j^{ik},$$

where de_j^{ik} is the additional resources, required for counteraction to resistance to motion of PVS subject or object Q_i^k of project Π_k in direction of motion N_j to complete the plan.

2. To create a reserve of time to overcome those areas of space, in which additional resistance occurs. The speed of motion of PVS decreases if problems arise, that is why additional time Δt is required in order to overcome it. If there is such reserve of time, project outcomes will be obtained in due time (the target point of PVS will be reached at specified time).

3. If possible, to lay the path through the areas of least resistance. This is reached by detailed study of the PVS.

7. Discussion of results of application of the methodology of project-vector management of educational environments

The system of planning and administration of SEE activity as a micro-service, integrated in the information-analytical system "Database of scientists of Ukraine", was created for implementation of the project-vector technologies of management of educational environment. The scheme of relationships between the micro-services, forming this system, is shown in Fig. 5

The following micro-services are considered in the system: information gathering, finding parameters (coefficient of resistance and coordinates of projects in PVS), data analysis (evaluation of SEE activity, identification of directions of scientific research, prediction of potentials of development of research directions). Based of the data, obtained from the system, it is possible to exercise management of the educational environment. In particular, it is possible to determine resources, required for implementation of scientific research projects of SEE, to perform the calculation of coordinates of vectors of projects administration. Subsequently, the system will be refined taking into account other problems of management of the educational environment in the project-vector space.

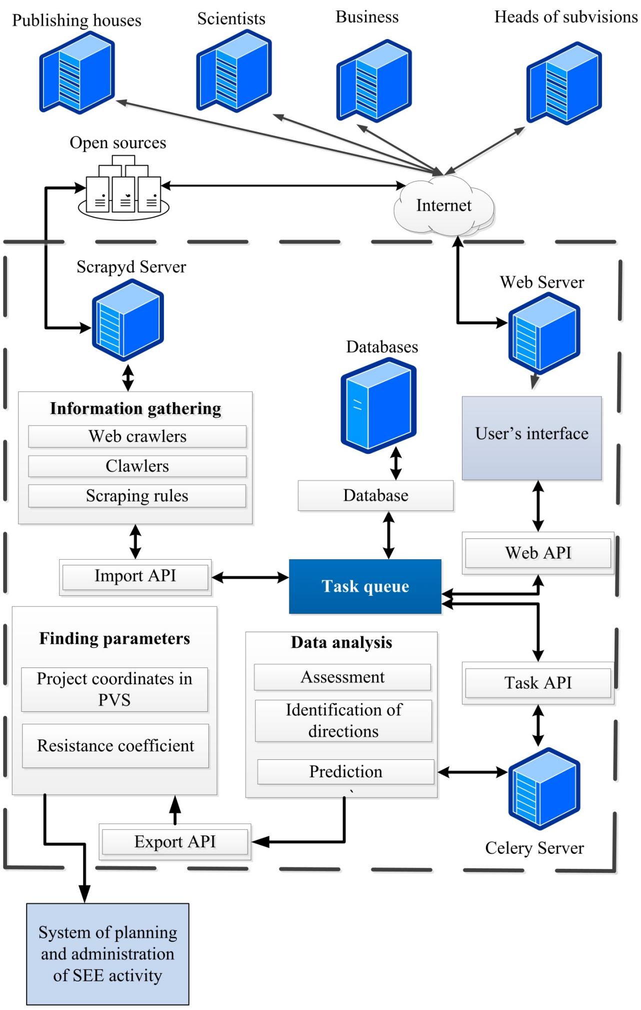

Fig. 5. Scheme of relationships between micro-services, forming the system of "Database of scientists of Ukraine"

The system was developed in the framework of fundamental scientific research "Methodological foundations of creation of information environment of management of scientific research of structural units of a higher educational institution of MES of Ukraine".

A special feature of the proposed applied information technology is integration in it of key approaches of the methodology of the project-vector management of educational environments. The methods, which are implemented in this information technology, enable one to adjust the motion of subjects or objects of space at any moment, specifically, to make changes in the components of administration vector to decrease the impact of unforeseen circumstances. The methods also allow estimation the trajectory, having the target point of motion. The use of the proposed methods is restricted by the fact that not all activities can be in assessed in the quantitative form at any arbitrary moment. In addition, the combined method of planning information-product projects is a NP-difficult problem. To overcome the specified restrictions, it is necessary to improve the assessment methods, specifically to create the ways of obtaining information about a PVS object or subject from several external sources, and then to coordinate the obtained estimations.

8. Conclusions

1. We developed planning tools of the technological component of the methodology of project-vector management of educational environments, which were implemented in applied information technology of planning and administration of SEE activity. The proposed combined method of planning information-product projects includes calculation of early and late terms of execution of works without regard to resources distribution and simulation of resources distribution between the works. The result of application of the combined method of planning information-product projects is the implementation plan of projects that are acceptable from the position of distribution of needs for resources and close to optimal by total time of projects' implementation.

2. Tools for administration of the technological component of the methodology of project-vector management of educational environments that were implemented in the applied information technology of planning and administration of SEE activities were created. The method for calculation of administrative vectors, which characterize the motion of projects in the project-vector space, was proposed. Vectors are constructed based of a set of scores of various aspects of project development. The use of these vectors allows exercising management of projects.

3. The influence of technical problems on projects in the part of administration of projects of subjects of educational environment was explored. This influence can manifest itself by the action of external factors, be the result of unprofessionalism of executors of a project, improper task planning, etc. The means for compensation of the impact of unforeseen situations on project implementation were considered. Such means include creation of a reserve of resources and time to overcome areas of space, in which resistance occurs, adjustment of the trajectory path so that it should pass through the areas of least resistance. We proposed formula for calculation of resistance to project's motion in the project-vector environment, based on the speed of motion of a PVS subject or object for a certain project, taking into account coefficient of resistance to motion in a specified direction.

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