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A CONCEPTUAL MODEL AND PROCESS MANAGEMENT METHOD OF THE PLANNING AND MONITORING OF THE WORKLOAD IN THE EDUCATIONAL ENVIRONMENT

Abstract: The article formulates the aims of HEI's activities, as well as approaches to managing all actions that ensure the achievement of the stated aims. The process approach is defined as the main one in the university management system. It is shown that the main directions of improving the activities of the university are the transition to the application of the process approach to the management of HEI and its informatization. On this basis, it is necessary to develop new, more modern university management systems that meet the contemporary requirements for the governance of multifunctional facilities and implement them in the form of process systems. We propose a conceptual model of the implementation of the functions to plan the educational process. The effects on planning functions are presented and the interrelation of these functions in the traditional form of planning is described. The tasks are formulated that need to be solved for modeling and optimizing business processes of planning and monitoring the academic workload to create an effective information technology for automating the functions of information processing. We propose a structural model for the implementation of information and procedural components of IT for planning and monitoring the educational environment. The implementation of this model in software provides the

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calculation of the optimal planned workload of students and teachers, considering the conditions in which the educational process is implemented.

Keywords: academic workload planning, educational environment, HEI management model, digital university, information technology of educational process planning.

Introduction and analysis of the research area

Successful solution of the problems facing Kazakhstan on the way of its integration into the global world economy is impossible without specialists with a high level of qualification. A special role in this process belongs to higher education institutions (HEIs), so it is especially important to ensure the stable operation of the university and the development of new educational programs. The necessary changes in the higher education system of Kazakhstan are not only in joining the Bologna process, but primarily in such organizational, technological, and functional improvements of higher education institutions that will allow them to reach the level of leading European universities.

In general, the educational potential of the country can be divided into two parts: the educational potential of the region and the educational potential of each educational institution [1]. A significant contribution to the development of regional tools for the methodology of educational project management was made by the school of Professor V.A. Racha. The work of this school, in fact, allowed us to create scientific and methodological tools for identifying, classifying, initiating, developing, and implementing educational projects at the regional level. At the same time, special attention was paid to managing the development strategy of higher education institutions in the region, supporting them in the competition for the implementation of projects aimed at improving the quality of education, and, of course, the commercial component of the educational institutions' activities [2]. Let us look at the main works.

The paper [3] shows the relationship between the educational potentials of the regions and the university and formulates the principles of managing the educational project potential of the region. These are the principles of external communication, competition, and accumulation. The stages of the life cycle that are highlighted, to manage the educational project potential of the region: conceptualization, preparation, bringing to regulatory requirements, acceptance. The implementation of the stages of the life cycle allows us to prepare the ground for effective functional activity, that is, an effective educational process [3].

The main task of the project manager is to ensure the work is completed on time, be responsible for the allocated money and perform in accordance with the terms of reference. Time, budget, and quality of work that can be called the main constraints that are imposed on the project [4-6]. To perform work in accordance with these constraints, the project manager's intuition is not enough. It is necessary to use a systematic approach [7]. For this purpose, the following principles should be used in the management of educational projects: [8] scientific approach; democratization; public participation; humanization; competence; optimization; objectivity and completeness of information; human resources; initiatives and activities; statehood.

The implementation of educational services in a region is determined primarily by the needs of enterprises and business entities operating in this territory [9]. Changes in the external environment (economic, political, social, transformational, etc.) cause adequate transformations in the needs of the labor market of the region over time. In such conditions, it is most appropriate to utilize the project-oriented management methodology to manage the development of regional education [3]. The paper [9] considers in detail the feasibility of a project-oriented approach to managing the development of regional education and the formation of a strong regional educational environment. The reasons for the emergence of such a project-oriented approach are described in the work [9]. They determine the implementation of the methodological aspect - the reform is based on the scientifically-based provisions of the project-portfolio management of regional education. The expediency of portfolio management is due to the multi-aspect nature of projects that should simultaneously be implemented within the framework of regional education development programs [9, 10, 11].

Another aspect of regional project management is given in the paper [12]. It is devoted to solving the problem of evaluating the activities of higher educational institutions from the project management model. It is based on the current state of project management in the university. The authors noted that the current stage is characterized by a transition from the management of individual projects to the project portfolio management. Based on the introduction of the regional level of management in the higher education system [9], a three-level project-oriented model of management of the higher education system is constructed and the basic principles of the concept to reform the management of the higher education system are formulated.

But it is impossible to manage projects, as well as manage project portfolios, without thorough analysis and evaluation [13, 14]. In the work [7], a model is developed for conducting a systematic project analysis, considering the specifics of educational projects. In this article, the project analysis is considered regardless of the specifics of the projects. It is shown that at the initialization and/or at the concept phase, the project idea is studied. But moving to planning, the investor must make a decision about the feasibility of implementing this project. At the same time, the investor involves an independent (external) expert, and assists him to make the appropriate decision. The author in the article [7] highlights the information features of the review of the educational project on the commercial aspect. The elements are shown that should be involved in the project for its review. And it is shown that educational and scientific projects have the peculiarity that the consumer of the project product is often unknown. Hence, there are difficulties with the analysis of such a project [13]. Nevertheless, the authors proposed a model and provided a practical scheme for the project analysis of regional educational projects [7].

It is not easy to implement project management at the regional level. This is indicated by the listed works. Since the education system is very complex [7], for management it is necessary to qualitatively decompose it into simpler parts (to perform decomposition) [15, 16, 17, 20]. To do this, firstly, it is necessary to classify all its entities. If we are talking about project management, then it is necessary to classify projects qualitatively [16, 17]. And to do this, it is necessary to select the classes that are most relevant to the realities of the development of the educational sphere. Kazakhstan has almost no experience in implementing clusterization projects, especially in the field of education. The paper [15] defines the essence of clustering projects in the regional educational environment. The features of such projects that should be considered in the initialization phase are highlighted. From the point of view of project management methodology, clusterization projects of the regional educational environment are positioned as a kind of organizational projects in the field of education aimed at achieving a comprehensive result [18]. The paper [15] shows that the content of clusterization projects is determined by stakeholders who receive values from educational projects. These are:

- the educational institutions themselves, whose main value is their competitive advantages in the educational market;
- the population of the region as the main consumer of educational services;
- business;
- the State.

The use of clusterization projects in the field of education makes it possible to simplify the management system of the regional educational environment, and automatically increases its efficiency and quality [15, 16].

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But there is another obstacle to implement project management in regional educational projects [9], which leads to a weak implementation of project management methods [19]. Thus, in the article [9] it is shown that in the Law "About Higher Education" the three-component model of the higher education system does not allow to trace the necessary links between the subjects of management at the regional level. This is a barrier to implement the project approach. Therefore, the authors of the paper [9] proposed a four-component model. Proposals on the competence of local self-government bodies are given. The implementation of these proposals will allow us to move to realize individual strategic objectives at the regional level through the portfolios of projects and programs [2, 3].

A number of conclusions can be drawn from the analysis:

Conclusion 1: to implement project-oriented management at the regional level, it is necessary to use the methods of portfolio or multi-project management [9, 10, 11].

Conclusion 2: What was discussed above in this analysis is one aspect of applying the project management methodology. But it also needs to be applied to manage the development of education at the national and institutional levels. Therefore, we can talk about individual educational environments that require a project-based approach.

Conclusion 3: effective management of the region project potential will allow educational institutions to create competitive advantages in the educational market.

Main material

Before proceeding to the development of methods and tools that ensure effective management of the processes of planning and monitoring the academic workload, we will determine the aim of using these processes.

Definition 1: The aim of planning the workload of teachers is to form a workload that corresponds to the state standards and to the classification of teachers for the selected period (most often – for a year).

Definition 2: The aim of planning the workload of students is to obtain such an academic workload that allows to form the knowledge, skills, and abilities of students organically and consistently under the impact of teachers in accordance with the needs of the state to train highly qualified specialists.

Definition 3: The aim to monitor the academic workload of students and teachers is to obtain information about the compliance of the actual volume of academic workload with the planned one to stimulate the work of teachers and to create such corrective effects on the planning process that will lead to its improvement.

Achieving this aim is possible only through the development and implementation of effective systems for managing the process of planning and monitoring the volume of academic workload. We will consider a scheme for managing the process of planning and monitoring the volume of academic workload. In the scheme the determination of the initial state is based on the standards for calculating the academic workload and the university curricula, and the final state is formed with the use of software and information tools (Fig. 1).

Attention is drawn to the presence of two feedbacks, the origin and function of which are different by nature and the nature of the impact:

s_1 – this feedback, which by the nature of occurrence, is a consequence of the analysis of the calculated academic load and the lessons schedule. According to the classification, this is a negative feedback with a periodic action. By directly affecting the planning object before and during its use, it leads to its changes.

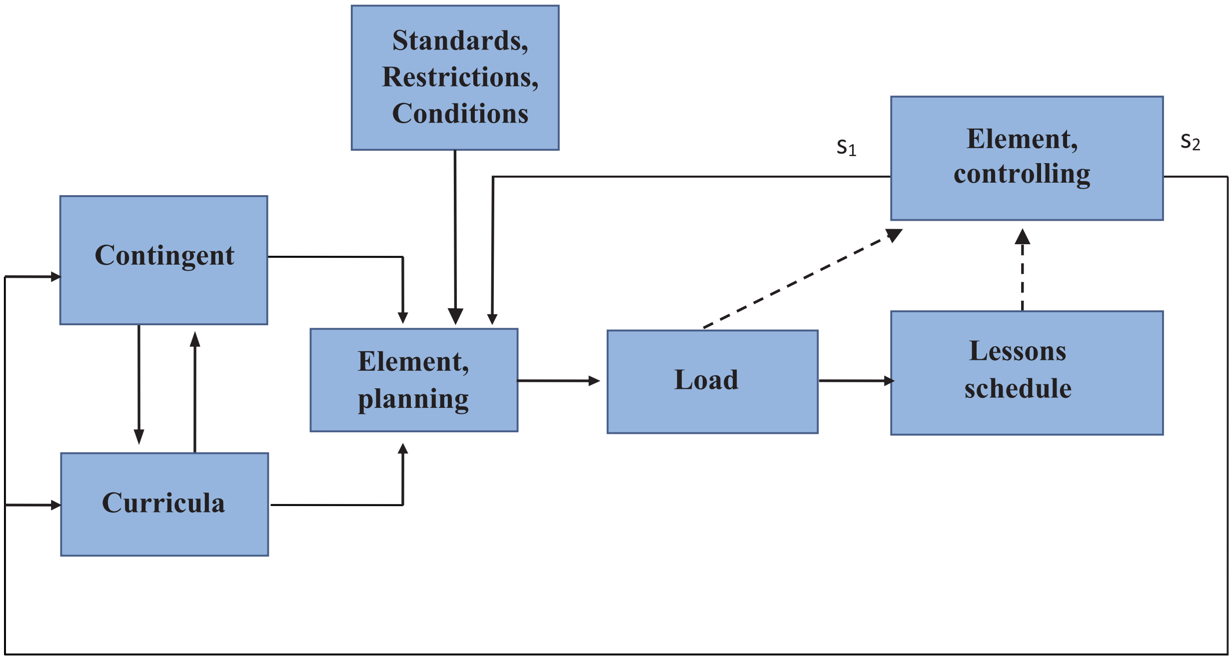

Fig. 1. Conceptual model for managing the process of the planning and monitoring of the workload in the educational environment

s_2 – this is feedback related to the assessment of the compliance of the calculated volumes of educational work with the desired course of the educational process. It is negative and persistent and is implemented in the form of administrative actions, but only in relation to the plan of the next academic year.

The information flow through s_2 feedback allows one to make changes to the curriculum, or to activate actions to increase the number of students. Since the information technology of planning and monitoring of the educational environment (ITPMEE) ensures the ordering of the learning process and improves the quality of the distribution of the workload, this will have a positive impact on the educational process.

The source of information impact in these feedbacks is the actions to monitor the educational process.

The unified form of planning the volume of academic workload requires a unified form of presentation of information, which occurs due to the action of feedback s_2. Therefore, it is necessary to use automated forms of data processing, which occurs during calculating the planned amount of academic workload. It is necessary to develop the structure of the information environment and methods and means of information technology for planning and monitoring the volume of workload. Only in this case, it will be possible to effectively plan the volume of academic workload and reliably analyze its results, through feedback s_1.

Structuring of information technology for planning and monitoring the educational environment

In the context of the implementation of the Bologna Process, the requirements to the standardization of information material that is mastered by students and ensures their correct response in the field of professional activity are increasing. In fact, we are talking about the formation of a level of quality of the educational process, which develops into the necessary quality of the activities of specialists. The progressive changes that are taking place in the field of education in Kazakhstan require the solution of important tasks to ensure the effective work of higher educational institutions, the development of new educational programs, and

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improving the quality of education. All this cannot be done without the use of effective information technologies for managing the educational process.

To implement the concept of "Digital University", it is necessary to adhere to certain stages of digital transformation within the framework of the developed conceptual model of digital transformation of the educational environment. We present "Digital University" as a set of information objects, each of which is used in the activities of departments and employees of the university, as well as information procedures that ensure the formation of these objects (Fig. 2).

The set of information objects is represented as a set: $U = \{u_k\}, k = \overline{1, y}$. The sources of content of the "Digital University" objects are many other objects and subjects of the university and the external environment, which in one way or another participate and influence the educational process.

It is advisable to consider the formation of the values of an information object as a certain procedure. Information objects are linked by information transformation procedures. The implementation of such procedures is appropriate if the values of all information objects, that are the input attributes of the procedure, are formed.

$$z_j = < f_{j1}, f_{j2}, \ldots, f_{js}, \ldots f_{jn} >, \quad [1]$$

where f_{js} – an action to transform an information resource of a procedure into an information product of the same procedure.

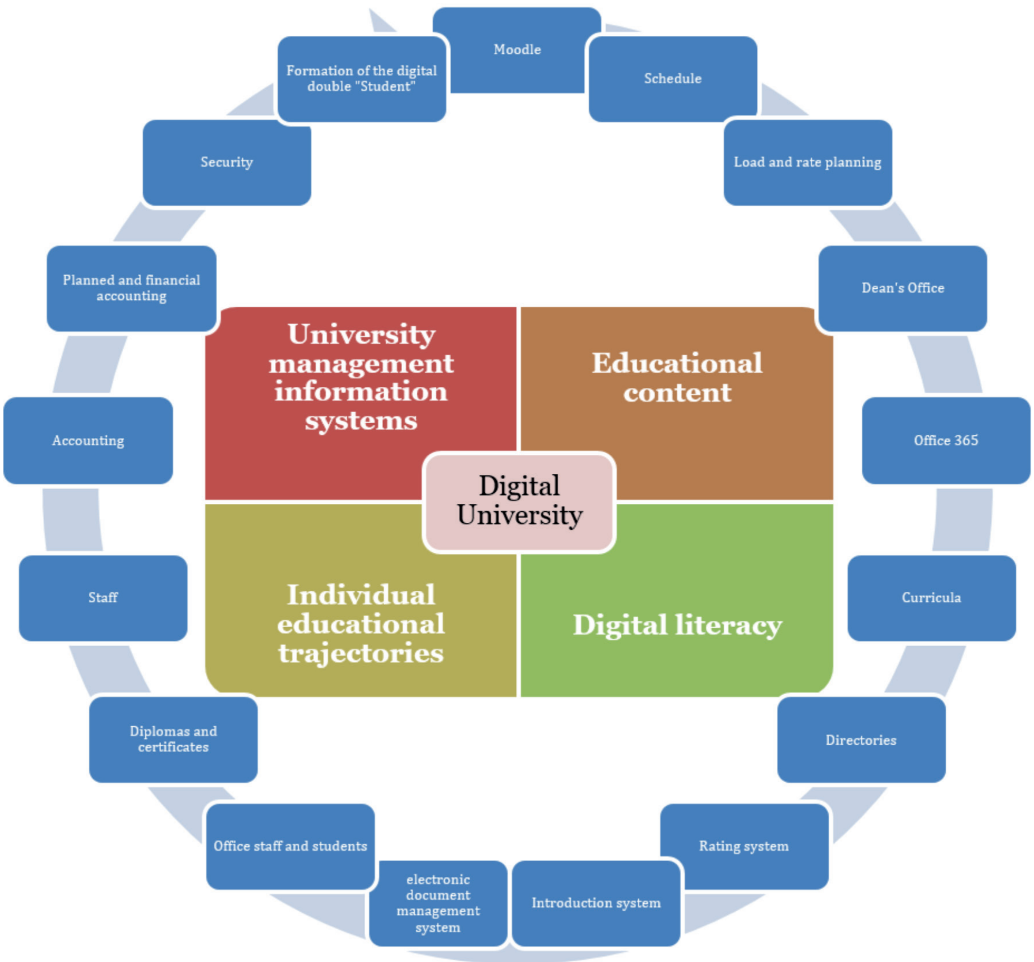

Fig 2. Conceptual model of digital transformation of the educational environment

It is advisable to consider the formation of the values of one information object as a certain procedure. In essence, information procedures are an interface between various information objects. Any object has a set of information transformation procedures. Each procedure of the object has many properties that determine the rate of information processing and the degree of importance of the source information for the educational process.

The information procedure provides a technologically complete information product that can be used in the university.

The description of the separate stages of the technological process of forming the values of information objects is presented through the implementation of information procedures.

Under the complex information and educational environment of the university, we will understand it in the form of a formula:

$$\text{“Digital University”} \subset K \times I \times T, \qquad [2]$$

where K – functional tasks of the university; I – information content of functional tasks; T – technology for filling information objects and solving functional problems.

Definition 4: “Digital university” is a set of information objects and information procedures in accordance with the structure of information processing technology in the Services of the university. The main role in the implementation of information procedures is played by specialists of the university services.

Before deciding within the functional task of the university, it is necessary to designate (fill) information objects. The values of information objects are formed in the university services based on normative and methodological documents using the intellectual apparatus of specialists, software tools and formal information processing procedures.

Filling the data in the information objects of the “Digital University” is provided by implementing a system of procedures for processing information in the departments of the university. The set of links is determined by the order of formation and use of the information resource of “Digital University”. So, we can formally define the technology of filling information objects of “Digital University” in the form of a formula:

$$T = \langle U, Z \rangle \qquad [3]$$

where U – systems of procedures for processing information;
Z – information procedure.

To implement such a technology, it is necessary to create a rational information management scheme in the functional divisions of the university. This will allow us to create truly effective university management systems based on the application of modern management methodologies for complex organizational and technical systems and implement them in the environment of software and information management tools of the university.

There are two stages of filling information objects with data:

1. Obtaining information from documents that come from outside or from the subjects of the process of managing the development of the university.

2. Obtaining information based on the use of: formal data processing procedures; software tools; databases of standard management decisions; knowledge and skills of employees of university services.

Each procedure can be implemented:

1. In the process of performing production functions by employees of the university services in the traditional (manual) mode.

2. Using software tools that implement appropriate methods and algorithms for information processing.

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Each information procedure reflects some rules for converting the content of information objects of one type into information objects of another type:

$$u_z = z_x(U_y),\ p_z \in U,\ U_y \subseteq U,\ u_x \in U \quad [4]$$

To form a single information object, one information procedure is implemented over other information objects.

In the aggregate of information objects, one can always find such subsets, the filling of which creates a new quality in the complex information environment. So, getting the value of uj0 through the implementation of the information procedure $u_{j0}=z_j(u_{j1},u_{j2},...,u_{jn})$ is possible only with the values of the information objects as $u_{j1},u_{j2},...,u_{jn}$. Thus, the set of information objects $u_{j1},u_{j2},...,u_{jn}$ creates a new quality in the information environment - the quality of joint actions.

Now there is a task of constructing such a scheme for the implementation of information functions and procedures, which provides the most effective formation of the values (definition) of the information environment of university projects.

The implementation of an information system in an organization is a complex process, especially when it comes to an integrated information system, the complexity of which lies precisely in its comprehensive coverage of various departments and other organizational units of the educational institution – different both in function and in priority. Taking this into account, it is necessary to introduce a scheme for implementing a comprehensive information system that would consider both the priority of work and the time for their implementation. We can take the axiomatic statement that the implementation should be carried out in the shortest time, but the units that have a higher priority should be included in the integrated information environment first, regardless of the time that needs to be spent on their information content. It is necessary to find a way of implementation in which the information filling of the objects of the "Digital University" would take place in the shortest time, but not so much that the "Digital University" as soon as possible would begin to work effectively, for this it is necessary that the objects with a higher priority are filled first.

There is a problem of choosing the optimal sequence of filling objects of "Digital University" due to their priority. This means that the condition must be met as:

$$p_i > p_{i+1} \quad [5]$$

where p_i – priority of the i-object of "Digital University".

The implementation of content, object selection, and digital transformation will be described in the following scientific articles.

At the heart of any management are the processes that ensure the organization, planning and control of the implementation of plans. It is in these processes that all management decisions are made. The effectiveness of these solutions directly depends on the completeness, reliability, and timeliness of information about the educational process. It is for this purpose that information systems and technologies for managing the educational process are created. Thus, there is a need to create information systems and technologies that would allow you to plan the educational process quickly and efficiently. This issue is primarily relevant in connection with the use of a credit-module system for organizing the educational process in a higher educational institution and the need to develop educational and methodological support for training specialists.

The result of the implementation of the functions for planning the educational process is the answer to the following questions:

1. What is the volume of academic workload of students in each semester by each of the disciplines in the context of types of classes.

2. What types of classes are taught by teachers and in which groups (with which students) they conduct.

3. What is the volume of the workload of teachers planned to be performed in each semester for each of the disciplines in the context of the types of loads.

4. What is the volume of teacher workload performed in each semester for each of the disciplines in the context of the types of loads.

5. Place and time of classes.

6. What reporting documents should be prepared at the end of the semester or academic year, who should do it, when and who should sign them, and where they should be stored.

The answer to these questions is formed in the process of implementing information technology for planning the volume of academic workload of students and teachers. To solve problem 1, the functions of planning students' academic workload are automated. The answers to questions 2-4 are formed in the process of automating the functions of planning the workload of teachers. In the ITPMEE component, which provides the implementation of lesson schedule planning functions, task 5 is solved. And, finally, the reflection of the fact of the implementation of the academic workload is implemented by the ITPMEE component, which is responsible for monitoring the plans. Thus, the answer to question 6 is formed. The place of the components of planning and monitoring the volume of academic workload in the educational process management system is shown in Figure 3.

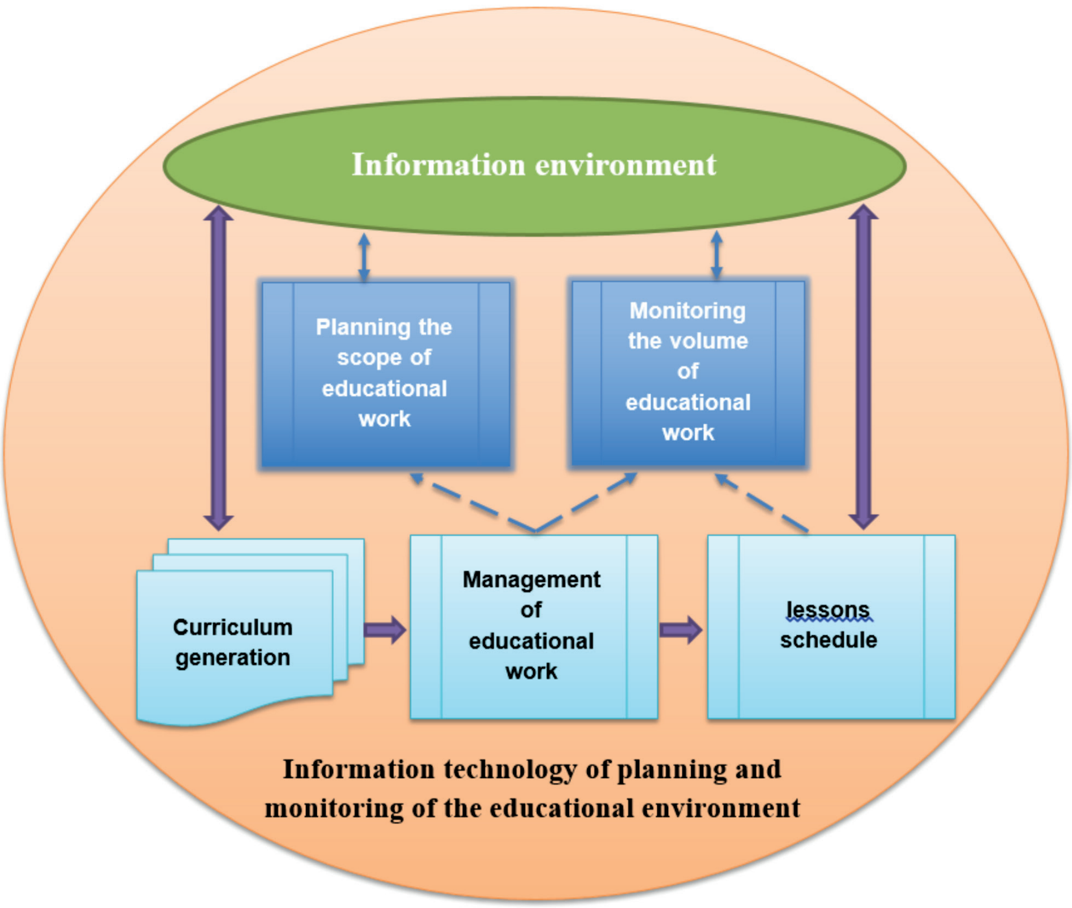

Fig. 3. Components and tasks of Information technology of planning and monitoring of the educational environment

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The ITPMEE information environment, which reflects both the activity processes and the management processes when planning and monitoring of the workload of students and teachers, can be represented by many instances of ITPMEE information templates and functional components of ITPMEE [21, 22].

To form the information and functional structure of the ITPMEE, we will take as a basis the functions related to the business processes of planning and monitoring of the educational work at the university. We will provide the statistical part of the ITPMEE information environment with a set of information templates (incoming, outgoing, and working forms of electronic documents and forms of documents on printed media).

Definition 5: The ITPMEE Information Template is the forms of incoming, outgoing and working documents, orders, instructions, messages, reports, database table structures, electronic information exchange standards and other layouts that are used in the process of planning and monitoring of the academic work of students and teachers:

$$\Delta = \{\delta_j\}, j = \overline{1,m}, \quad [6]$$

Δ – Set of ITPMEE information templates;

δ_j – ITPMEE information template;

m – number of ITPMEE information templates.

Each template is characterized by:

$$\delta_j = < a_j^{\delta}, P_i >, \quad [7]$$

P_i – a subset of the fields of the ITPMEE information template (for example, a table for calculating the academic workload of university teachers)

a_j^{δ} – title of the ITPMEE information template.

The main ITPMEE information templates are shown in Table 1.

There are ITPMEE information templates that correspond to the forms of statistical reports and reflect the result of planning and monitoring of the educational work volume at the university. In addition, ITPMEE information templates can be used to describe frequently used internal (working) documents, or to create standards for computer-based information exchange.

An instance of the ITPMEE information template is a specified ITPMEE information template that provides information on planning or monitoring of the educational work:

Table 1. ITPMEE Information Templates

Symbol	Title of the ITPMEE information template
δ_1	Curriculum Template
δ_2	Working curriculum template
δ_3	The form of planned educational work of teachers
δ_4	Student's Individual Plan Form
δ_5	Lesson schedule form
δ_6	Template of the structural and logical scheme of the specialty
δ_7	Educational process schedule template
δ_8	The form of reporting on the completed educational work

Definition 6: An instance of the ITPMEE information template is a completed (in whole or in part) document according to some ITPMEE information template and is specified by a unique name in the ITPMEE:

$$E = \{e_{ji}\}, j = \overline{1, m}, i = \overline{1, n_j}, \quad [8]$$

E – Set of instances of ITPMEE information templates;
e_{ji} – an instance of the ITPMEE information template;
n_j – number of different instances of the ITPMEE information template δ_j

As follows from the above definition each instance of the ITPMEE information template can be described as:

$$e_{ji} = < a_{ji}^e, \delta_j, \mathrm{I}_{ji} >,$$

a_{ji}^e – an unique name of the instance of the ITPMEE information template (for example, the academic workload of the Associate Professor of the Department of Higher Mathematics, Bezfamilny I.I.);
I_{ji} – information in the fields of the ITPMEE information template.

The ITPMEE information template instances are filled in during the implementation of the ITPMEE information functions, which should ensure the effective implementation of the business process of planning and monitoring of academic work volume of students and teachers.

Definition 7: The ITPMEE information function is a model of relations between the types of ITPMEE information templates, which allows one to automatically implement one or more functions of the process of planning and monitoring of the volume of educational work of students and teachers, or its information support.

The ITPMEE information functions are a dynamic part of the ITPMEE information environment. Each ITPMEE information function is an algorithmic one that uses the ITPMEE information base in some program that implements the corresponding methods and algorithms for information processing. The arguments of the ITPMEE information functions are instances of the ITPMEE information templates. Each function reflects some rules for converting the values of various ITPMEE information templates into an instance of the ITPMEE information template.

Definition 8: The implementation of the ITPMEE information function is to display the ratio specified by the function on a set of instances of the ITPMEE information template.

$$\Phi = \{\phi_k\}, k = \overline{1, L}, \quad [9]$$

Φ – Set of ITPMEE information functions;
ϕ_k – ITPMEE information function;
L – number of ITPMEE information functions.

The ITPMEE information function is implemented when the arguments are a set of filled (specified) instances of the ITPMEE information template:

$$e_{ji} = \phi_k(E_k^*), \quad [10]$$

E_k^* – a subset of instances of the ITPMEE information template, which are the input information (information resource) for the function ϕ_k, which forms an instance of the ITPMEE information template e_{ji} (information product of the function ϕ_k).

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The main role in the implementation of ITPMEE information functions is played by specialists of the university departments, as well as software and information tools that automate these functions. Before deciding on the amount of educational work, it is necessary to form the parameters (arguments) of the ITPMEE information functions. The values of the instance fields of the ITPMEE information templates are formed in the university services based on normative and methodological documents using the intellectual apparatus of specialists and formal information processing procedures. We can highlight two stages in the process of forming the values of the ITPMEE information template instances:

1. Obtaining information from documents that come from outside or from the subjects of the university management process.

2. Getting new information based on usage of:

- formal data processing procedures;
- formal knowledge-based inference procedures;
- databases of standard management solutions;
- knowledge and skills of employees of the university services.

In the set of instances of the ITPMEE information template, one can always find such subsets, the filling of which creates a new quality in the information environment. This quality is the ability to implement a certain ITPMEE function. So, getting the value through the implementation of the ITPMEE function $e_{ji} = \phi_k(E_k^*)$ is possible only after the formation of instances of the ITPMEE information templates related to the subset E_k^*. Thus, the set of instances of ITPMEE information templates E_k^* creates a new quality in the information environment - the quality of joint actions, and the ITPMEE functions that form this set form the ITPMEE component.

Definition 9: The ITPMEE component $(Z = \{z_j\}, j = \overline{1,s})$ is a set of ITPMEE information functions $\phi_r \in \Phi_k^*, \Phi_k^* \subset z_j$ that form the argument values of another ITPME function $\forall e_{ji}^* \in E_k^* \, \exists \phi_r \Rightarrow e_{ji}^* = \phi_r(E_r^*)$.

In contrast to the ITPMEE information functions, the ITPMEE component provides a technologically complete information product. A product can be used for planning and monitoring of educational work of students and teachers at the university.

The description of the separate stages of the technological process of planning and monitoring of educational work will be presented through the implementation of the ITPMEE components.

Then, the ITPMEE information environment is a set of instances of ITPMEE information templates and components. Under the ITPMEE information environment, we will understand the subset that is included in the Cartesian product:

$$H \subset E \times Z \quad [11]$$

To create a rational scheme for the implementation of ITPMEE components, it is necessary to find a rational order for the formation of instances of ITPMEE information templates (information technology products), which will correspond to the structure of business processes for planning and monitoring of educational work. Therefore, the task arises of constructing such a scheme for the implementation of ITPMEE components, which provides the most effective formation of values (definition) of instances of the ITPMEE information template.

Method of reverse calculation of the volume of educational work of the educational environment

The method provides the implementation of feedback in the management system for planning and monitoring of educational work of students and teachers (Fig. 4). From the point of view of the impact on the effectiveness of the educational process, it is very important to consider the predicted information when planning the educational work volume, which will determine how "convenient" the plan is in the real educational process. In the traditional approach to planning (curriculum → workload planning → schedule planning), each stage does not consider the "opportunities" for the effective implementation of the next stages, based on the decisions made. Therefore, in the structure of information technology for planning the educational process, the author suggests solving the tasks based on predicting the effectiveness of problem solutions at the following stages. After all, with the traditional approach, the lesson schedule is the ultimate goal of the technology of planning the educational process. In the traditional scheme of educational process management, three stages are implemented:

1. The lesson schedule is formed by the function:

$$\Theta(R) = f_{10}(\mathrm{H}^C(R), \mathrm{H}^B(R), B(R), k_{51}) \quad [12]$$

The arguments of this function are the volume of academic work of students $\mathrm{H}^C(R)$ and teachers $\mathrm{H}^B(R)$, as well as the curricula $B(R)$ and restrictions determined by the fund of classrooms and laboratories k_{51}. Thus, the determination of whether there are enough classrooms and laboratories for the calculated load is performed after this load is formed.

2. In turn, the calculation of the educational work volume is performed using formalized functions. For students:

$$\mathrm{H}^C(R) = f_9(G, W, O(R)). \quad [13]$$

In turn, the calculation of the volume of educational work is performed using formalized functions. For students:

The arguments of this function are the schedule of the educational process G, the disciplines studied by students W and the academic load that is set by the curricula $O(R)$.

For teachers:

$$\mathrm{H}^B(R) = f_8(P, X, O(R)), \quad [14]$$

The arguments of this function are a set of teachers P, a set of peer review assessments of the possibility of conducting classes by teachers X, and the academic load that is set by the curriculum $O(R)$.

3. As can be seen from point 2 the basis for calculating the educational work volume is the curriculum:

$$O(R) = f_6(B(R), Q(R)), \quad [15]$$

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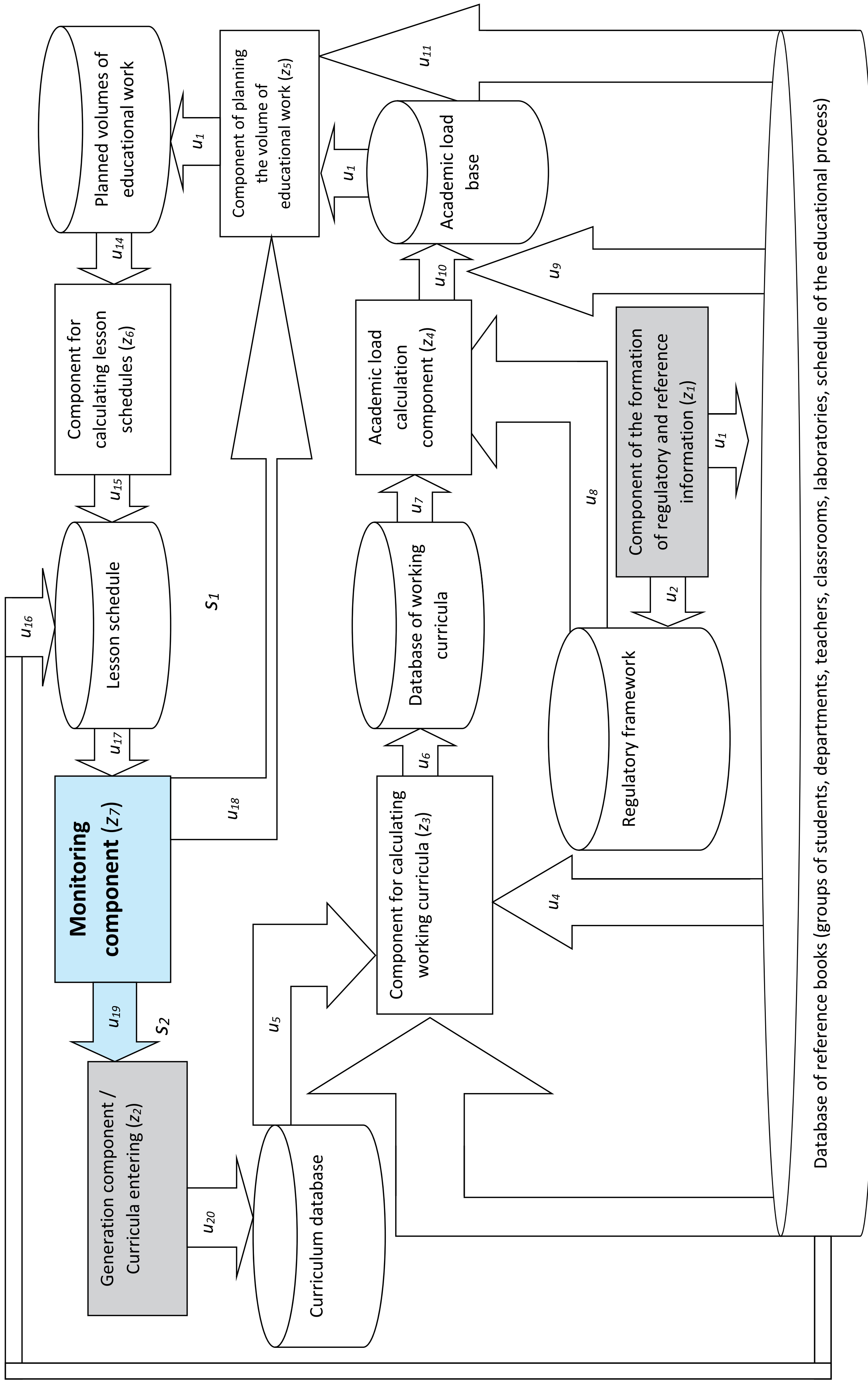

Fig. 4. Structural model of implementation of ITPMEE information and procedural components

The input information of the function is the working curriculum and the number of students $Q(R)$. The initial one is the volume of the students' academic load and the work of the teachers that is included in the curricula. Thus, it is the curricula that determine the academic load used in calculating the volume of academic work. And the volume of academic work is the basis for calculating the lesson schedule.

The above approach to the calculation of both the schedule and the planned academic load does not allow one to adjust the volume of the classroom load, which is set by the curriculum for the actual contingent of students, the staff of teachers and the available classroom fund. Therefore, it is proposed to implement a method for managing the volume of educational work of students and teachers through feedback, which provides information about the volume of educational work of students and teachers, and the workload of classrooms and laboratories in the ITPMEE component, which calculates the planned volume of educational work (feedback $\mathbf{s}_1$ – see Fig. 4), as well as in the curriculum design component (feedback $\mathbf{s}_2$ – see Figure 4).

It is proposed to implement a structural model (Fig. 5). The method of reverse planning of the educational process, which is based on the adaptation of curricula to the requirements of the university, includes the following stages:

1. Calculation of the academic load according to the existing curricula.
2. Calculated academic load meets the requirements: the available classrooms and laboratories; the desirable academic workload per teacher - the end of the optimization of the curricula.

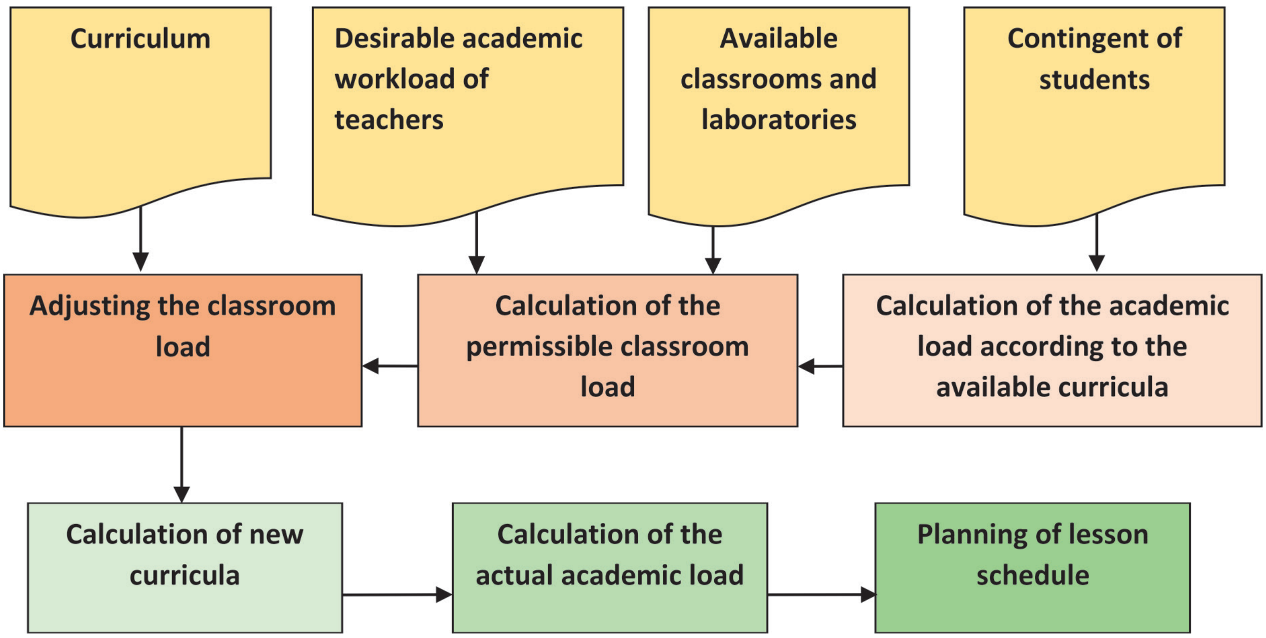

Fig. 5. Structural model of information technology for planning of the educational process, adapted to the requirements of the university

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3. Calculation of the academic load that meets the specified requirements. In fact, a part of the existing academic load is determined, considering the priorities in teaching disciplines (in which it is possible to reduce the classroom load, and in which it is not) and the workload of the classrooms. It is implemented in several stages:

3.1. Calculation of the average academic load for the departments of the university.

The average volume of classroom academic load of departments is determined from the formulas:

$$v_{avg}^{ауд}(K_i,R)=\frac{\sum_{l=1}^{n}\sum_{s}\sum_{j=1}^{m_i}\left(\rho_{slj}^{1}(K_i)+\rho_{slj}^{2}(K_i)+\rho_{slj}^{3}(K_i)+\rho_{slj}^{4}(K_i)\right)}{\sum_{l=1}^{n}\left[\frac{\sum_{s}\sum_{j=1}^{m_i}\left(\rho_{slj}^{1}(K_i)+\rho_{slj}^{2}(K_i)+\rho_{slj}^{3}(K_i)+\rho_{slj}^{4}(K_i)\right)}{\sum_{s}\sum_{j=1}^{m_i}\left(\rho_{slj}^{1}+\rho_{slj}^{2}+\rho_{slj}^{3}+\rho_{slj}^{4}\right)}\cdot\frac{g_l(R)}{N_i^{викл}(R)}\right]}, \quad [16]$$

$v_{avg}^{ауд}(K_i,R)$ – average classroom academic load of the department K_i in the academic year R;

ρ_{slj}^{1} – volume of work of teachers to conduct lectures on a discipline d_{lj} in the s semester;

ρ_{slj}^{2} – volume of work of teachers to conduct practical classes on a discipline d_{lj} in the s semester;

ρ_{slj}^{3} – volume of work of teachers on conducting laboratory classes for a discipline d_{lj} in the s semester;

ρ_{slj}^{4} – volume of work of teachers to conduct individual work of students for a discipline d_{lj} in the s semester;

$\rho_{slj}^{1}(K_i)$ – volume of work of teachers of the department Ki on conducting lectures for a discipline d_{lj} in the s semester;

$\rho_{slj}^{2}(K_i)$ – volume of work of teachers of the department Ki on conducting practical classes on a discipline d_{lj} in the s semester;

$\rho_{slj}^{3}(K_i)$ – volume of work of teachers of the departme.nt Ki on conducting laboratory classes on a discipline d_{lj} in the s semester;

$\rho_{slj}^{4}(K_i)$ – volume of work of the teachers of the department Ki to conduct individual work of students on a discipline d_{lj} in the s semester;

$g_l(R)$ – total number of students who study according to the curriculum A_l;

$N_l^{викл}(R)$ – standard of the ratio of the number of students and teachers according to the curriculum A_l for the academic year R.

The average volume of the academic load of the departments is determined from the formulas

$$v_{avg}^{заг}(K_i,R)=\frac{\sum_{l=1}^{n}P_l^{пл}(K_i,R)}{\sum_{l=1}^{n}\left[\frac{P_l^{пл}(K_i,R)}{P_l^{пл}(R)}\cdot\frac{g_l(R)}{N_l^{викл}(R)}\right]}, \quad [17]$$

$v_{avg}^{заг}(K_i,R)$ – average academic load of the department K_i in the academic year R;

$P_l^{пл}(K_i,R)$ – academic load of the department K_i in the academic year R according to the curriculum A_l;

$P_l^{пл}(R)$ – academic load according to the curriculum A_l in the academic year R.

3.2. The volume of classes that are held in deficient classrooms:

$$v^a_s(L_i) = \sum_{l=1}^{n}\sum_{j=1}^{m_l}\left(\rho^1_{slj}(L_i) + \rho^2_{slj}(L_i) + \rho^3_{slj}(L_i) + \rho^4_{slj}(L_i)\right), \qquad [18]$$

$v^a_s(L_i)$ – total academic load on the classroom L_i in the semester s;

$\rho^1_{slj}(L_i)$ – volume of work of teachers to conduct lectures on a discipline d_{lj} during the s semester in the classroom Li;

$\rho^2_{slj}(L_i)$ – volume of work of teachers to conduct practical classes on a discipline d_{lj} during the s semester in the classroom L_i ;

$\rho^3_{slj}(L_i)$ – volume of work of teachers to conduct laboratory classes on a discipline d_{lj} during the s semester in the classroom L_i ;

$\rho^4_{slj}(L_i)$ – volume of work of teachers to conduct individual work of students on a discipline d_{lj} during the s semester in the classroom L_i .

3.3. Highlighting the most overloaded element of the educational process.

$$\mu^{каф}_i(R) = \frac{v^{заг}_{avg}(K_i, R)}{K_4}; \mu^a_j(R) = \frac{\sum_{s \in R} v^a_s(L_j)}{K_5}, \qquad [19]$$

$\mu^{каф}_i(R)$ – coefficient of overload of the department K_i in the academic year R;

$\mu^a_j(R)$ – classromm overload coefficient L_i in the academic year R;

K_4 – teacher workload limits;

K_5 – resource constraints.

$$K_i : \max_{K_i}(\mu^{каф}_i(R)); \; L_j : \max_{L_j}(\mu^a_j(R)).$$

3.4. If $\mu^{каф}_i(R) > \mu^a_j(R), \mu^{каф}_i(R) > 1$ then there is a reduction in the volume of the classroom load in the curricula for the disciplines of the departments according to the scheme:

3.4.1. Finding new volumes of classroom work:

$$\overline{v^{ауд}_{avg}(K_i, R)} = v^{ауд}_{avg}(K_i, R) - v^{заг}_{avg}(K_i, R) \cdot (\mu^{каф}_i(R) - 1), \qquad [20]$$

$\overline{v^{ауд}_{avg}(K_i, R)}$ – new (satisfying condition K_4) volumes of classroom work of the department K_i in the academic year R;

3.4.2. Finding the coefficient of reducing the volume of classroom work:

$$k^{ауд}_{avg}(K_i, R) = \frac{\overline{v^{ауд}_{avg}(K_i, R)}}{v^{ауд}_{avg}(K_i, R)}, \qquad [21]$$

$k^{ауд}_{avg}(K_i, R)$ – coefficient of reduction in the volume of classroom work of the department K_i in the academic year R;

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3.4.3. Finding the value of reducing the classroom load in the curricula for the disciplines of the department:

$$\Delta v_{avg}^{ауд}(K_i, R) = \sum_{l=1}^{n} \sum_{s} \sum_{j=1}^{m_l} \left[\left(\rho_{slj}^1 + \rho_{slj}^2 + \rho_{slj}^3 + \rho_{slj}^4 \right) \cdot \beta_{lj}(K_i) \right] \cdot \left(1 - k_{avg}^{ауд}(K_i, R)\right), \quad [22]$$

$\Delta v_{avg}^{ауд}(K_i, R)$ – difference in the size of the academic load between the initial and target volumes of academic work in the curricula for the department K_i in the academic year R.

$\beta_{lj}(K_i)$ – coefficient that determines the affiliation of a discipline to the professional direction of the department ($\beta_{lj}(K_i) = 1$ – affiliated, $\beta_{lj}(K_i) = 0$ – nonaffiliated).

3.4.4. Calculation of the sum of the priorities of the disciplines that the department teaches:

$$R(K_i, R) = \sum_{l=1}^{n} \sum_{j=1}^{m_l} \left(100 - r_{lj}\right) \cdot \beta_{lj}(K_i), \quad [23]$$

$R(K_i, R)$ – sum of the priorities of the disciplines taught by the department K_i in the academic year R;

r_{lj} – priority of a discipline d_j of curriculum A_l;

Priority determines the degree of "immutability" of the volumes of disciplines. It changes from 1 (change without restrictions) to 100 (never change).

3.4.5. Calculation of the volume of classroom hours in the curricula corresponding to the actual academic load:

$$\forall A_i, D_j : \overline{v_{lj}^1} = v_{lj}^1 - \frac{\Delta v_{avg}^{ауд}(K_i, R)}{R(K_i, R)} \cdot \left(100 - r_{lj}\right) \cdot \beta_{lj}(K_i), \quad [24]$$

$\overline{v_{lj}^1}$ – a new volume of lectures.

$$\forall A_i, D_j : \overline{v_{lj}^2} = v_{lj}^2 - \frac{\Delta v_{avg}^{ауд}(K_i, R)}{R(K_i, R)} \cdot \left(100 - r_{lj}\right) \cdot \beta_{lj}(K_i),$$

$\overline{v^2}$ – new volume of practical lessons.

$$\forall A_i, D_j : \overline{v_{lj}^3} = v_{lj}^3 - \frac{\Delta v_{avg}^{ауд}(K_i, R)}{R(K_i, R)} \cdot \left(100 - r_{lj}\right) \cdot \beta_{lj}(K_i),$$

$\overline{v^3}$ – new volume of laboratory classes.

$$\forall A_i, D_j : \overline{v_{lj}^4} = v_{lj}^4 - \frac{\Delta v_{avg}^{ауд}(K_i, R)}{R(K_i, R)} \cdot \left(100 - r_{lj}\right) \cdot \beta_{lj}(K_i),$$

$\overline{v^4}$ – new volume of individual work of students.

3.5. If $\mu_i^{каф}(R) < \mu_j^a(R), \mu_i^a(R) > 1$, there is a reduction in the volume of the classroom load in the curricula for the disciplines that are held in the classroom L_j:

3.5.1. Finding the necessary difference in the volume of classroom work:

$$\overline{v_s^a(L_i)} = v_s^a(L_i) - \text{K}_5, \quad [25]$$

$\overline{v_s^a(L_i)}$ – new (satisfying condition K_5) volumes of classroom work by classroom L_i.

3.5.2. Finding the coefficient of reducing the volume of classroom work:

$$k^a(L_i) = \frac{\overline{v_s^a(L_i)}}{v_s^a(L_i)}, \qquad [26]$$

$k^a(L_i)$ – classroom load reduction coefficient L_i.

3.5.3. Finding the value of reducing the classroom load in the curricula for the disciplines of the department:

$$\Delta v_{avg}^a(L_i) = \sum_{l=1}^{n}\sum_{s}\sum_{j=1}^{m_l}\left[\left(\rho_{slj}^1 + \rho_{slj}^2 + \rho_{slj}^3 + \rho_{slj}^4\right)\cdot \beta_{lj}^*(L_i)\right]\cdot\left(1 - k^a(L_i)\right), \qquad [27]$$

$\Delta v_{avg}^a(L_i)$ – difference in the size of the academic load between the initial and target volumes of academic work in the curricula by classroom L_i.

$\beta_{lj}^*(L_i)$ – coefficient that determines whether classes are held in the classroom for a discipline L_i (L_i ($\beta_{lj}^*(L_i) = 1$ – held, $\beta_{lj}^*(L_i) = 0$ – not held).

3.5.4. Calculation of the sum of the priorities of the disciplines that are held in the classroom L_i:

$$R(L_i) = \sum_{l=1}^{n}\sum_{j=1}^{m_l}\left(100 - r_{lj}\right)\cdot \beta_{lj}^*(L_i), \qquad [28]$$

$R(L_i)$ – sum of the priorities of the disciplines that are held in the classroom L_i.

3.5.5. Calculation of the volume of classroom hours in the curricula corresponding to the actual academic load:

$$\forall A_i, D_j : \overline{v_{lj}^1} = v_{lj}^1 - \frac{\Delta v_{avg}^a(L_i)}{R(L_i)}\cdot\left(100 - r_{lj}\right)\cdot \beta_{lj}^*(K_i), \qquad [29]$$

$\overline{v_{lj}^1}$ – new volume of lectures.

$$\forall A_i, D_j : \overline{v_{lj}^2} = v_{lj}^2 - \frac{\Delta v_{avg}^a(L_i)}{R(L_i)}\cdot\left(100 - r_{lj}\right)\cdot \beta_{lj}^*(K_i), \qquad [30]$$

$\overline{v^2}$ – new volume of practical lessons.

$$\forall A_i, D_j : \overline{v_{lj}^3} = v_{lj}^3 - \frac{\Delta v_{avg}^a(L_i)}{R(L_i)}\cdot\left(100 - r_{lj}\right)\cdot \beta_{lj}^*(K_i), \qquad [31]$$

$\overline{v^3}$ – new volume of laboratory classes, set by the curriculum.

$$\forall A_i, D_j : \overline{v_{lj}^4} = v_{lj}^4 - \frac{\Delta v_{avg}^a(L_i)}{R(L_i)}\cdot\left(100 - r_{lj}\right)\cdot \beta_{lj}^*(K_i), \qquad [32]$$

$\overline{v^4}$ – new volume of individual work of students, set by the curriculum.

3.6. Clarification of the volume of classroom work for compliance with the standard (1 / 3-2 / 3 of the total volume of work).

If, $\overline{v_{lj}^1} + \overline{v_{lj}^2} + \overline{v_{lj}^3} + \overline{v_{lj}^4} < (v_{lj}^1 + v_{lj}^2 + v_{lj}^3 + v_{lj}^4 + v_{lj}^5)/3$, then:

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$$\overline{\pi^1_{lj}} = \overline{v^1_{lj}} \cdot \frac{\overline{v^1_{lj}} + \overline{v^2_{lj}} + \overline{v^3_{lj}} + \overline{v^4_{lj}}}{(v^1_{lj} + v^2_{lj} + v^3_{lj} + v^4_{lj} + v^5_{lj})/3}, \qquad [33]$$

$\overline{\pi^1}$ – new volume of lectures, set by the curriculum.

$$\overline{\pi^2_{lj}} = \overline{v^2_{lj}} \cdot \frac{\overline{v^1_{lj}} + \overline{v^2_{lj}} + \overline{v^3_{lj}} + \overline{v^4_{lj}}}{(v^1_{lj} + v^2_{lj} + v^3_{lj} + v^4_{lj} + v^5_{lj})/3},$$

$\overline{\pi^2}$ – new volume of practical lessons, set by the curriculum.

$$\overline{\pi^3_{lj}} = \overline{v^3_{lj}} \cdot \frac{\overline{v^1_{lj}} + \overline{v^2_{lj}} + \overline{v^3_{lj}} + \overline{v^4_{lj}}}{(v^1_{lj} + v^2_{lj} + v^3_{lj} + v^4_{lj} + v^5_{lj})/3},$$

$\overline{\pi^3}$ – new volume of laboratory classes, set by the curriculum.

$$\overline{\pi^4_{lj}} = \overline{v^4_{lj}} \cdot \frac{\overline{v^1_{lj}} + \overline{v^2_{lj}} + \overline{v^3_{lj}} + \overline{v^4_{lj}}}{(v^1_{lj} + v^2_{lj} + v^3_{lj} + v^4_{lj} + v^5_{lj})/3},$$

$\overline{\pi^4}$ – new volume of individual work of students, set by the curriculum.

$$\overline{\pi^1_{lj}} = \overline{v^1_{lj}}, \overline{\pi^2_{lj}} = \overline{v^2_{lj}}, \overline{\pi^3_{lj}} = \overline{v^3_{lj}}, \overline{\pi^4_{lj}} = \overline{v^4_{lj}}.$$

Otherwise:

$$\overline{\pi^1_{lj}} = \overline{v^1_{lj}}, \overline{\pi^2_{lj}} = \overline{v^2_{lj}}, \overline{\pi^3_{lj}} = \overline{v^3_{lj}}, \overline{\pi^4_{lj}} = \overline{v^4_{lj}}.$$

A new volume of independent work of students on a discipline:

$$\overline{\pi^5_{lj}} < v^1_{lj} + v^2_{lj} + v^3_{lj} + v^4_{lj} + v^5_{lj} - \overline{\pi^1_{lj}} - \overline{\pi^2_{lj}} - \overline{\pi^3_{lj}} - \overline{\pi^4_{lj}}. \qquad [34]$$

1. Coordination and approval of new curricula.
2. Calculation of the academic load for the departments of the university.
3. Planning the lesson schedule.

Completion of curriculum improvement.

The implementation of the structural model of adapting the volume of classroom load shown in Figure 5 will allow us to form the curricula optimal and adapted to the conditions of the university, in turn, it normalizes the academic load of teachers, the volume of work of students and the load of classrooms and laboratories.

This approach will effectively automate the management of the educational process in higher education institutions.

Conclusion

The aims of the university's activities are formulated, as well as approaches to managing all actions that ensure the achievement of the formulated aims. The process approach is defined as the main one in the university management system.

It is shown that the main directions of improving the activities of the university are the transition to the application of the process approach to the management of the university and its informatization. On this basis, it is necessary to develop new, more modern university management systems that meet the new requirements for managing multifunctional facilities and implement them in the form of process systems.

A conceptual model of the implementation of the functions of planning the educational process is proposed.

The tasks are formulated that need to be solved for modeling and optimizing business processes of planning and monitoring of the volume of educational work to create an effective information technology for automating the functions of information processing in these business processes.

The components of the ITPMEE information environment are identified and their formal definition is given. These are: ITPMEE information templates, instances of ITPMEE information templates, ITPMEE functions, ITPMEE components, links that determine the order of ITPMEE functions, information technology.

It is shown that the procedure for performing the information functions of ITPMEE depends on the technology of forming instances of the ITPMEE information templates and on the free resources (primarily the classroom fund) in the university.

The task is formulated to construct a rational scheme for the implementation of the information functions of ITPMEE in the planning and monitoring of the volume of educational work. To implement such a technology, a rational scheme for implementing the information functions of ITPMEE has been created. This made it possible to create truly effective information management systems at the university based on the application of modern approaches to managing complex organizational and technical systems and to further implement them in the environment of software and information tools for managing the educational process.

A structural model for the implementation of ITPMEE information and procedural components is proposed. The implementation of this model in software and information tools provides the calculation of the optimal planned volumes of educational work of students and teachers, considering the conditions in which the educational process is implemented.

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