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Instrumental implementation of the educational process model to improve the rating of the universities

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Taking into account the requirements of modern society for future specialists, the learning process becomes more complex and many-sided every year. At the same time the time frame of training cannot be increased. In such contradictory conditions, electronic means of management and support of the learning process come to the rescue.

The purpose of this research is the development of an information system that would allow to carry out quality management in terms of the results of the learning process.

The work is of practical importance, as algorithm for assessing the learning process is proposed, which is implemented and integrated into the information system of monitoring, evaluation, correction of the learning process for any discipline. With the help of the developed module it is possible to evaluate the degree of mastering competences by students and to carry out long-term planning of the educational process.

In the work, the process of teaching students is modeled on the basis of studies of general information processes in educational environments. A dynamic model is constructed in the notation of colored hierarchical Petri nets. The simulation model of one of the stages of mastering the discipline of the curriculum is analyzed.

Methods of statistical analysis developed an algorithm for rating the work of the department. The equation of the discriminant function was obtained, which served as a rating for real departments of the Moscow City University.

The model of the educational process and the rating algorithm of the departments is implemented in the additional module of the corporate system of the university. This module is located in the subsystem of department management. When designing the module, functional requirements were formulated. The processes that automate the information system are described. The prototype information was developed on the platform "1C: Enterprise".

Key words and phrases: model, assessment of the department, educational process, rating, information system.

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1. Introduction

Relevance of the topic. A specific indicator of the development of national Russian higher education is the position of universities in world university rankings [1]. The popularity of various systems for assessing the activities of a higher educational institution has determined their recognition and widespread usage [2]. One of the indicators of a high rating of the university is the quality of education [3].

The key structural element that is responsible for the educational process is the academic department (department). Evaluation of the results of the department is an important indicator of the university's assessment in the educational services market in general [4].

Effective management of the university is impossible without a corporate information system, which is an integrated system consisting of many subsystems [5]. One of these subsystems is the module for managing the activities of the department.

The task of the authors is to modernize the module by implementing the proposed algorithms for evaluating the activities of the department and for planning the educational process on the basis of its analysis.

The objects of the research are the informational processes taking place in the structural subdivision of the university aimed at teaching students.

The subject of the study is the process of developing an information system unit for evaluating and adjusting learning process of students of a higher education institution.

2. Problem Statement

Analyze the existing processes associated with the study of students of a certain discipline:

- Construct a dynamic model of the learning process;
- Carry out a research into the activities of the Moscow University Department;
- Build a mathematical model of the rating evaluation of the department;
- Formulate the requirements for the module being developed;
- Develop a prototype of the information system module for strategic planning of the educational process.

3. Modeling the Education Process

The study of the process of education is a very important task for the management of educational institutions, and consequently, an improvement of training quality of future specialists [6]. The construction of mathematical models makes it possible to study the regularities of the process of the educational process, which is part of the educational process.

A change in the state of an object is called a process [7]. Educational process can be discussed in relation to students as studied objects. The educational process is part of the educational system [8]. The differences are presented in table 1.

To construct a mathematical model, the authors proposed the definition of an informational object – an educational process that reflects its formalized structure.

The educational process (UE) is a continuous, dynamic, deterministic process with rigidly defined, limited resources, consisting of elements:

- lecture forms of training;
- laboratory forms of training;
- Seminar classes;
- practical lessons;
- technological practice;
- independent work;
- internship;
- Knowledge control.

Resources for the implementation of the educational process:

	Educational system	Educational process
Objectives	The main goal – the devel- opment of individual char- acteristics of the student, the promotion of his cogni- tive independence through subject knowledge, skills and habits.	The main goal is the assim- ilation of subject knowl- edge, skills
Content	On the forefront are gen- eral cultural values.	The content is determined by the curricula.
Process	The activity of the teacher is the unity of education and upbringing.	Training is conducted with the teacher's dominant role

Table 1 Comparison of Educational Process and Educational System [9]

- faculty;

the audience;

various benefits;

computer and multimedia audiences;

corporate networks, etc.

The authors have studied information flows that occur during training [10].

A student can be represented as a finite automaton, with a finite set of states that depend on external influences. Therefore, it was decided to construct a dynamic model in the notation of Petri nets. To implement the dynamic model, the CPN Tools software [11] is used, which is freely distributed for non-profit organizations.

Each network position corresponds to the state of the learning process. Transition is the study of any topic: tests, completion of laboratory work, exams, course projects, etc. Transition triggering corresponds to the successful completion of the study of the topic. Each token is added a color that stores the attributes: either "passed" or "failed". Following the instructions, the chip moves along the network (Figure 1).

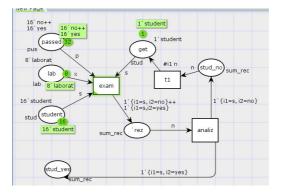


Figure 1. Fragment of a colored Petri net learning process

To evaluate the performance of the model, the matrix method of network analysis was applied [12]. A necessary condition for the attainability of any network marking was fulfilled. The analysis showed that only two combinations of transitions are suitable: t_3 , t_2 , t_1 and t_1 , t_2 , t_3 . This conclusion is confirmed by figure 2.

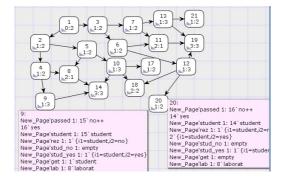


Figure 2. Tree of attainability

4. Algorithm of the Rating Evaluation of the University Departments' Work

Experimental data of the twelve departments of the Moscow City University for 25 indicators was used to construct a mathematical model [13]. To reduce the dimensionality of the model, the most significant indicators were selected using the correlation analysis. The significance was verified on the basis of a matrix of correlation coefficients.

As a result, construction of the model involved 16 indicators: Hirsch index, the average wage, the average score of students on admission exam, etc. With the help of cluster analysis (hierarchical clustering) department were divided into two classes: the "effective" and "ineffective". The selection was based on the difference in the mean values of the metric variable. The generalized indicator of the activities of the departments was calculated (Fig. 3).

The investigated objects were divided into "Effective" — K5, K4, K10, K1, K2, K7; "Inefficient" — K3, K9, K6, K11, K8.

In the process of analysis, the equation of the discriminant function was constructed (1)

$$D = -7,458 * x_1 + 5,762 * x_2 + 3,481 * x_3 + 30,173 * x_4 - 16,599 * x_5 + 8,190 * x_6 - 11,449 * x_7 + 6,867 * x_8 - 3,367 * x_9,$$
(1)

where x_i is the indicator of the department.

Using the constructed model with a probability of 0.999, it is possible to predict the evaluation of the work of structural units without special studies of their indicators.

The prototype of the information system implementing the algorithms described above was developed on the "1C: Enterprise" platform [15–17].

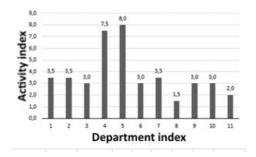


Figure 3. Generalized activity index of the department [14]

5. Basic Concepts Used in the Information System Module

The performance indicators of the department and the results of students' training are assessed with points for each unit of work. Objects of accounting are various types of work performed by the department or students in the learning process. Achievements are indicators for a certain period of time. The rating of the department is the sum of all points scored for the whole period of work. Accounting rules are automated summation [18, 19].

Processes that automate the module of the information system [20–22]

- Definition of the system of indicators for evaluating the work of the department.
- Determination the success of student learning.
- Determination of rules for calculating the rating of the department and the performance of each student.
- Formation of recommendations on the prospective planning of the educational process.
- Construction of rules for the success of the department.
- Creation of a variety of customizable reports.

Functional requirements for the information system module [23]

- Ensure the collection of data on the learning process in the system;
- Ensure the storage in a single database of all information about the activities conducted, the type of employment, the completed, unsuccessful tasks, tests, the number of students who have passed and not passed control, various types of activities of the department;
- Provide preprocessing of data using methods of statistical data analysis;
- Automate the construction of a learning process model based on data on the learning process in the electronic learning system and its editing on the basis of a hierarchical colored Petri net;
- Automate the process of creating various reports.

The database stores lists of students and lists of the faculty members of the department (Figure 4).

To account for the progress of students, scores are added for each reporting period for each subject in the schedule (Figure 5).

In general, the repository information system of the department are various test and verification tasks. The results of the checks are sent to the developed module, where the rating of the student is evaluated.

Examples of summary reports of the results of the department are presented in Figures 7, 8.

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Figure 4. The command interface list of the catalog "Students"

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		12	10:00			30						
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		9.0	00:00			60						
		10	30:00			30						
5	Wednesday			TP-141	Lifecycle management of		PRAC	Seryshev R. V.	207Sh	Sherenetevsky st., d. 29		
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Figure 5. The main form of the document "Class schedule"

6. Results

The dynamic model of the educational process in the notation of Petri nets allowed to assess the degree of mastering the educational material on discipline based on class performance and performing practical work by a group of 16 students. One person was unsuccessful, which coincides with the real results.

The algorithm of the department's activity was developed for eleven departments of the Moscow City University with 25 indicators. The twelfth department served to test the performance of the model. The faculties were divided into two groups: "effective" and "not effective." A discriminant equation has been constructed, which made it possible to assign the twelfth department to the group "effective", which corresponds to reality.

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Figure 6. Report form with test results

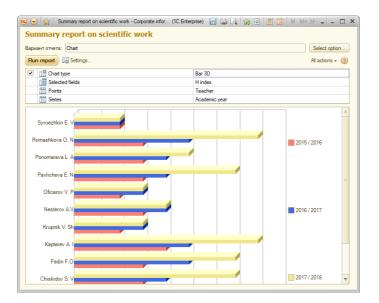


Figure 7. Report on the results of scientific activity: chart

The proposed model and algorithm are implemented as a module of the information system of the department on the platform "1C: Enterprise". Examples of interfaces are shown in Figures 4–7.

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Figure 8. Report on the results of scientific activity: summary table

7. Conclusions

The developed model of the educational process and the algorithm of the rating evaluation of the structural subdivision of the university is implemented in the module of the information management system of the department. This will improve the quality and effectiveness of university management in general, as based on reliable and objective methods of evaluation and prospective planning. The implementation of the module will simplify the collection of data on the work of departments and the quality of the educational process and assist with formation of various types of reporting.

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