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CONSTRACTION OF DISTRIBUTION MODELS OF THE UNIVERSITY EDUCATIONAL WORK VOLUME

Abstract: With the advent of new time requirements for the quality of educational services, which is influenced by management in functioning business processes, existing research in the field of resource allocation in the management of complex processes, namely the calculation of the teaching load of university teaching staff, was studied. The purpose of the research in this article is to develop functional and mathematical distribution models of the university educational work volume, as well as an algorithm for optimizing the generation of educational flows and initialization of academic groups, considering the specifics of disciplines and classroom funds. The algorithm is based on the construction of all business processes implemented during the formation of educational streams and groups. The functional model described for the process of distributing the volume of educational work includes the definition of the main functions, their relationships, input and output data, as well as the criteria and restrictions that govern this process. The mathematical model is based on the representation of all types of educational work of departments of educational programs as a discrete set of resources that must be distributed between educational departments in accordance with the assumptions and restrictions accepted at the university. Data mining and operations research techniques were used to write the functional model. Empirical and quantitative methods were used to write a mathematical model. Thus, a new methodology has been developed for solving complex optimization problems that arise when modeling and optimizing the distribution of the volume of educational work of a university. It should be noted that comparative experiments under labor-intensive and time-limited conditions confirm the effectiveness of this technique in solving problems of distributing the amount of educational work among departments of educational programs, which in turn contributes to the implementation of high-quality software.

Keywords: functional model, mathematical model, decision support algorithms, teaching load, educational work, types of educational work, educational flows, educational process.

Introduction

Planning the teaching load at Astana IT University, being one of the responsible, complex and time-consuming tasks solved at the stage of preparing the educational process at the university, is carried out by the departments of educational programs. When planning work, the Department of Academic Activities strives to improve the quality of work in order to achieve the best results for the types of educational work: classroom and extracurricular. This paper

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discusses a system for distributing the volume of academic work between university departments for further distribution of the teaching load of teaching staff within educational departments.

The solution to the problem of quality of education, its optimization was described in the works [1], [2]. The working model for optimizing the distribution of the teaching load of teaching staff is especially relevant in the following conditions [3], [4]:

- when forming new educational programs at the request of the labor market or introducing new disciplines into existing educational programs or closing outdated educational programs.
- with a dynamically changing student population (transfers from other universities, expulsion of students, academic leave);
- with a variety of forms of education (full-time education, distance learning, academic mobility, dual education, training in a double-diploma program).

Based on comparative analysis we note that when forming the volume of educational work of departments of educational programs, the key factor is the formation of educational streams and groups involved in calculating the teaching load of teaching staff. The working model for optimizing the distribution of academic groups among academic streams is especially relevant in the following conditions:

- depending on the specifics of educational programs [4];
- when distributing the classroom fund, considering specialized rooms and laboratories;
- when distributing specialized disciplines between teachers;
- depending on the specifics of the disciplines taught;
- with a dynamically changing student population, including changing academic groups within one educational program or two different ones;
- with a variety of training formats (online lectures, video lectures, dual training).

Previous studies in this direction [5] showed that all of them, to one degree or another, describe the mechanisms for distributing the teaching load of university teaching staff, but practically do not pay attention to the methodology for distributing academic work. It is considered several methods based on the following criteria:

a) determination of the qualification level of the department of educational programs, with each discipline assigned to several departments;

b) approval of the average teaching load of the university teaching staff, while the load is uneven across all educational departments;

c) increasing the efficiency of the scientific potential of the educational department, while there is an uneven distribution of classroom and extracurricular work.

As it can be seen, these decision-making criteria are quite ineffective, which in turn causes the urgency of the problem.

Currently, one of the possible ways to increase the success of distributing the teaching load at a university is an algorithm based on deep learning, which is presented in the works [6], [7]. The implementation of the conceptual provisions of the theory of educational process management is impossible without the use of modern tools based on automation and the use of process management principles for optimizing the teaching load. For example, in the work [6], models and algorithms were proposed for various formulations of the task defined in this paper. In this regard, a synthesis of the studied methods was carried out and a generalized method for planning the teaching load was proposed, which is based on models and a decision support algorithm [7]. In this work, it is also a linear programming model for solving problems related to the generation of the educational streams and groups at the university.

Let us present the concept of the teaching load of a university. The volume of academic work of teaching staff at the university is divided into types: classroom work and extracurricular work. Classroom work includes the following: lectures; practical/seminar sessions; laboratory classes; office hours; studio/review classes; checking written work; midterm, endterm; consultation; exam; extracurricular activities include the following: management of coursework (projects); supervision of the diploma theses (projects); supervision of master's theses; supervision of doctoral dissertations; management of students' research works (SRWM, SRWD); management of educational, pedagogical, industrial (professional), research, pre-graduate practice; work in the State Attestation Commission (participation in the state/complex exam, participation in the defense of theses/master's/doctoral dissertations); groups advisory; employment of graduates; management of educational and methodological work; and others.

To effectively write business processes for load optimization, it is necessary to create an algorithm and models. The initial data in the distribution of the volume of educational work of university departments according to Fig. 1 are: a working curriculum (WC) for the planned academic year, compiled on the basis of individual curriculum (IC) of students with mandatory components and components for choosing disciplines, a student population and classroom fund, as well as criteria and restrictions.

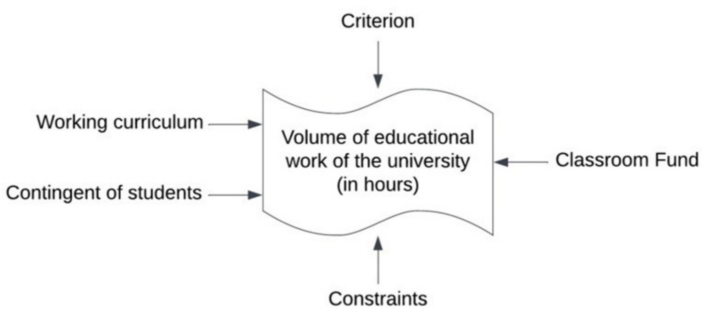

Figure 1. Input data of the distribution problem of the university educational work volume

The introduction of e-learning systems leads to the emergence of large information arrays that are studied by the method of educational data analysis (EDM) to information produced by the university. The problems and challenges facing the EDM are analyzed in the works [8], [9]. Here we also use these methods of analyzing educational data and consideration of the processes of the following information arrays, namely statistical, correlation and regression analysis.

An individual curriculum (IC) is drawn up for each student after completing the registration procedure for the disciplines. Then a curriculum is formed for one academic year, which reflects the volume of credits for each discipline in terms of trimesters and classroom hours for each discipline. As the trimesters progress, the academic workload tends to increase gradually. Thus, in paper [10], the academic workload is shown to be evenly distributed between semesters and courses within the program. The algorithm for designing personality-oriented educational programs based on the analysis of educational process data is presented in the work [11]. In this paper an analysis of the structure and content of competence-oriented curricula is conducted, considering the definition of a compromise of interests of all social groups participating in the educational process. Namely, the compliance of all prerequisites and post requisites of disciplines, the compliance of related educational programs in the construction of educational streams, and so on.

The student contingent reflects the number of students, master's students, doctoral students registered in the disciplines of the planned academic year in the context of each educational program and each course of study.

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The classroom fund is divided into types of classrooms and the number of seats in each classroom is available for classes.

After analyzing the initial data, learning flows for lectures and study groups for practical/seminar or laboratory classes are formed, which is the basis for calculating the total teaching load for the university and for each department of educational programs.

The criterion determines the decision-making rule for assessing the optimal formation of educational streams and groups in them.

Constraints form the rules according to which learning streams should be formed and groups should be assigned to streams. Restrictions can come from both the academic department and educational departments in accordance with the university development strategy and the department's strategic development plan. Restrictions and criteria may include regulations, internal regulations of the educational institution and other regulatory documents.

As a result of the process of optimizing the distribution of the university's teaching load, two key output elements are formed: the distributed teaching load across the university and the assessment of this distribution. Distributed teaching load is the volume of teaching load for all types of classrooms and extracurricular work by courses and trimesters. Assessing the distribution of teaching load is a process or mechanism for monitoring how effectively the distribution was carried out, with the possibility of adjusting optimize the educational process.

Functional Model

A functional model is a representation of a process or system that focuses on the functions or operations performed by the system under various conditions. It describes what the system does or should do, without specifying exactly how those functions are performed. Functional models are used to analyze requirements, design systems, and document system functions [12].

The functional model described for the learning load distribution process includes the definition of the main functions, their relationships, input and output data, as well as the criteria and constraints that govern this process [12], [13]. This model helps you understand what tasks need to be completed, who is responsible for them, and how they interact to achieve the end goal. The short description of functional model was presented in [12], here all block concepts of created functional diagram are created.

In Fig. 2 shows the initial level of the functional model "Form the teaching load of the department" with the flows of incoming and outgoing information, mechanisms for performing the specified action, and elements of control and management on the basis of which it is performed.

Functional diagram presented in Fig. 3, is a decomposition of the context diagram A0 "Form the teaching load of the department" and consists of four blocks: block A1 "Enter/modify source data", block A2 "Form the number of group streams by disciplines", block A3 "Calculate the academic workload for the university", block A4 "Approve the teaching load for each department."

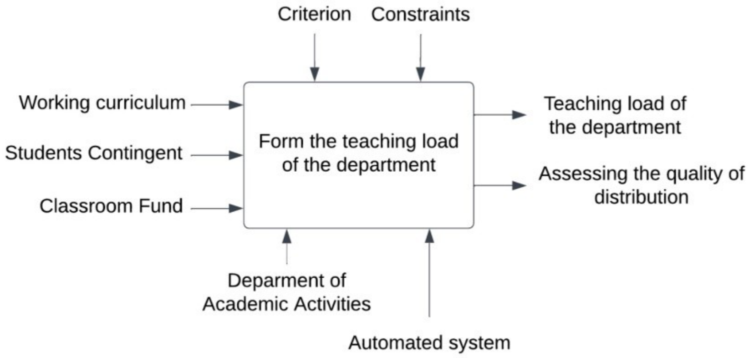

Figure 2. Context diagram A0

Each of the blocks A1-A4 represents separate sub-stages within the overall process of distributing the teaching load. They reflect the overall appearance and function of the system. Block A1 is the starting point in the process of optimizing the distribution of the teaching load, where the collection of information is organized, including the curriculum and WC of educational programs, IC, data on the student population and the classroom fund. The prepared data serves as the foundation for subsequent analysis and optimization of load distribution, which allows the university to more effectively manage the educational process and use its resources. At this stage, the academic department enters initial data or adjusts planned data that will be used to compile group flows. Initial data may include the name of the discipline, the name of the educational program, the number of students, the number of academic groups, the number and type of audiences. The process requires attention to detail and precision, as the initial information serves as the basis for all subsequent load balancing operations. After entering the data, a procedure for their verification and approval follows. This ensures that all critical parameters are taken into account, and that the data is ready for use in the automated system for the subsequent stage - generating training flows and initializing groups.

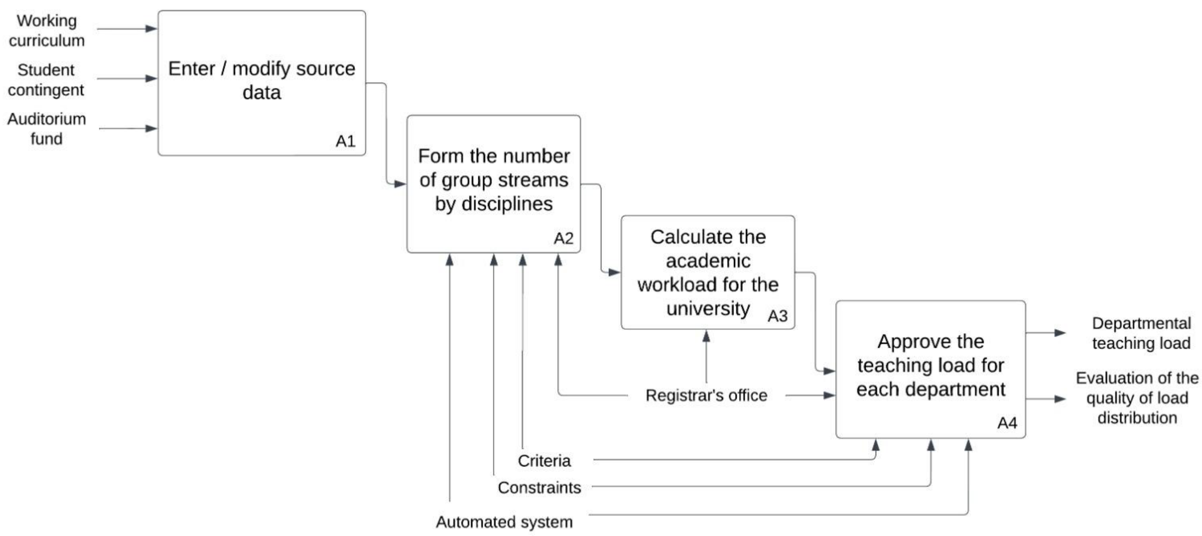

Figure 3. Context diagram decomposition A0

In block A2, the key stage of load optimization occurs. Here, the required number of educational streams for conducting lectures, practical, and laboratory classes is established based on the provided data on disciplines, the number of students, as well as types of audiences, taking

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into account various criteria and restrictions. It is important to take into account the availability of classrooms, the type of discipline taught and other factors. The goal of the process is to form the optimal number of educational streams and groups for the efficient use of resources and classroom funds. It is important to achieve a balance between available resources and the educational needs of students and teachers so that each discipline is subsequently adequately represented in the schedule. Automated systems help the university effectively structure the educational process, adapting it to the needs of students and the capabilities of the educational institution. Assigning a certain number of educational streams and groups to disciplines is critical for ensuring the quality of the educational process, as it directly affects the schedule and workload of classrooms.

At stage A3, the total volume of academic work is consolidated at the university level. The block for assigning the teaching load of a university details the distribution process, including the assignment of lecture, practical, laboratory loads, independent and control work of students, exams and other types of classroom educational work, as well as extracurricular types of work, such as the management of coursework, dissertations, and so on for all departments. Here decisions are made on the distribution of the total teaching load between various educational departments, considering the goals of the educational program. This stage underlies the further distribution of the teaching load at the level of each department, and then teachers.

Block A4 represents the stage at which the volume of academic work is distributed between the departments of the university. The Academic Activities Department organizes and coordinates this process, considering the specifics of each department, such as area of specialization and availability of resources.

At the final stage of optimizing the distribution of teaching load, the quality of load distribution is monitored and assessed. An analysis is made of the distribution of workload between departments, its compliance with the goals of the university and the needs of students. The data obtained is used to adjust the process of distributing the teaching load in the future. An important part of this stage is feedback from process participants to discuss the results of the assessment and develop recommendations for improving the process. This stage plays a key role in ensuring the effectiveness of the educational process and maintaining a high level of education. Assessing the quality of the formation of study streams and groups is a comprehensive check, which can lead to a return to previous stages to correct data or change the restrictions of educational streams and groups. This ensures continuous improvement of business processes and maintains a high standard of the educational process at the university.

Distribution algorithm

An overview of the main algorithms used in resource allocation problems is presented in [13], [14]. The modified algorithm for searching paired combinations in a graph is proposed, which allows solving the problem of optimal distribution of workload between teachers in the work [12]. In this work we consider the description, input and output data, and features of the created algorithm for generating educational streams and initializing academic groups. The modified algorithm has been proposed, which allows solving the problem of optimally distributing the workload in the future between the teachers and the disciplines that this division is required to implement in the academic year.

Input data: information about disciplines, educational programs, academic groups, students and groups, classroom fund.

Checking input data: checking the correctness and completeness of the entered information (Fig. 4).

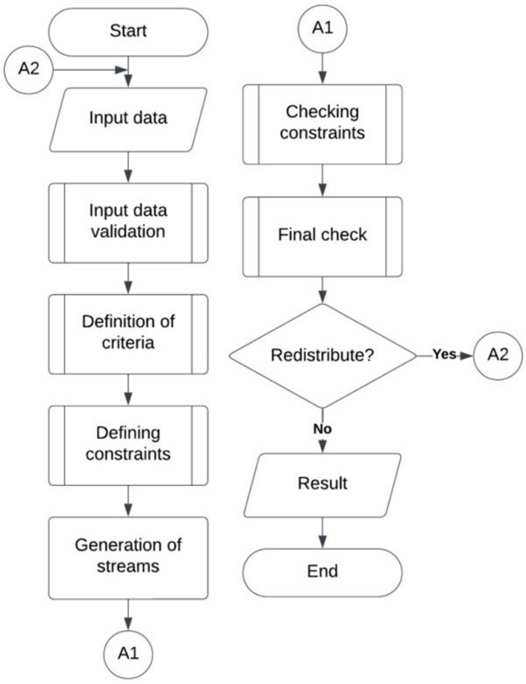

Figure 4. Algorithm for generating educational streams and initializing academic groups

Determination of criteria and restrictions: determination of criteria and setting restrictions for the formation of educational streams and groups. The first criterion for optimizing the formation of streams is to minimize the number of streams due to the limited availability of classrooms and vacancies, the second is the maximum available distribution of the number of students in each stream, the third is the maximum use of available classrooms, the fourth is the uniform distribution of students across educational streams. Restrictions on the formation of streams are the connection of the classroom fund to a particular discipline, as well as the number of eligible students per academic stream by type of academic work. For example, each classroom for a math block stream contains a maximum of 60 seats (the stream classroom is filled with a maximum of 3 groups), the remaining disciplines are distributed by a maximum of 40 to 120 local classrooms, depending on the number of students and distribution groups.

Generation of streams: formation of educational streams and initialization of academic groups for each discipline, taking into account established criteria and restrictions.

Checking criteria and restrictions: checking the compliance of all criteria and restrictions for each educational stream, adjusting educational streams and groups if necessary.

Final check: checking the final result to ensure there are no conflicts and optimal use of resources.

The result is the best option from a set of comparable feasible options for the distribution of educational flows.

The need to modify the algorithm is justified by the unevenness and variability of educational flows, the multi-criterial nature of the distribution of flows and the need to take into account the subjective characteristics of the distribution decision.

Mathematical Model

The mathematical model for optimizing resource allocation was developed to reduce the time required to make management decisions on resource allocation problems in the work [15], [16]. Let us present the main provisions of the mathematical model for distributing the teaching load of the university educational departments.

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Generating input data.

The organization and conduct of training sessions is carried out in the context of academic groups and streams. Let the university be assigned s educational programs (EP), for which classes should be conducted: $S_n = \{S_1, S_2, \dots, S_s\},\ n = \overrightarrow{1, s}$.

Each EP, in turn, has academic groups: $G_y^{S_n} = \{G_1, G_2, \dots G_g\},\ y = \overrightarrow{1, g}$, where y – group serial number, and g_n – number of groups per EP, calculated by the formula

$$g_n = \frac{N_n}{20} \tag{1}$$

according to the occupancy of one academic group of the university, where N_n – number of students in one EP.

According to the WC, in one academic year at the university, disciplines are taught in the following components: compulsory/university component (CC/UC): $D_i = \{D_1, D_2, \dots, D_v\},\ i = \overrightarrow{1, v}$, optional component (OC): $D_r = \{D_1, D_2, \dots, D_w\},\ r = \overrightarrow{1, w}$, depending on the discipline cycles.

We will define the following types of educational classroom work (lectures, practical classes, laboratory work, office hours, exam/defense), for which classes are planned: $F_j = \{F_1, F_2, \dots, F_k\},\ j = \overrightarrow{1, k}$.

Then the number of students enrolled in the *i, r*-th disciplines: $N_i = \sum_{n=1} N_n^i, N_r = \sum_{n=1} N_r^i$.

Generating the streams number of lecture classes with CC/UC/OC components of disciplines.

Note that lecture classes are conducted in educational streams with a contingent of 20 to 120 students, depending on the specifics of the academic discipline. For disciplines of the mathematical block, the maximum number of students in one stream is taken to be 60.

Let's calculate the number of streams for lecture classes with CC/UC/OC components of disciplines:

$$P_{ij} = \left\lceil \frac{N_i}{Z} \right\rceil, \quad P_{rj} = \left\lceil \frac{N_r}{Z} \right\rceil, \quad j = 1, \tag{2}$$

where $\lceil\ \rceil$ –denotes rounding a number up to a whole number,

Z – available number of seats in one stream, calculated using the following formula

$$Z = \begin{cases} 100\ B_l\ \ if\ \ l = 1, \\ 60\ B_l\ \ if\ \ l = 2, \end{cases} \tag{3}$$

where $B_l = \{B_1, B_2\} \in \{0, 1\},\ l = \overrightarrow{1{,}2}$ – belonging of the i-th or r-th discipline to the general $l = 1$ or mathematical block $l = 2$, determined by a Boolean variable.

Note that

$$P_{ij} = 1\ (j = 1) \Leftrightarrow \begin{cases} 20 \le N_i, N_r \le 120,\ l = 1 \\ 20 \le N_i, N_r \le 60,\ l = 2. \end{cases} \tag{4}$$

Let us set the following limit on the number of students allowed for one stream of lecture classes. Let there be a classroom fund for conducting training sessions with the following number of available seats:

$$\begin{aligned} A_m^l &= \{40{,}60{,}80{,}100{,}120\}, \quad m = \overrightarrow{1{,}5}, \quad l = 1, \\ A_m^l &= \{40{,}60\},\ m = \overrightarrow{1{,}2},\ l = 2. \end{aligned} \tag{5}$$

Then the restrictions on the students number in academic groups of different EPs for lecture streams with CC/UC/OC disciplines are as follows:

$$\textstyle\sum_n N_n^{ij} \le A_m^l,\ \sum_n N_n^{rj} \le A_m^l, \quad j = 1. \tag{6}$$

Generating the streams number of practical classes with CC/UC components of disciplines.

The streams number of practical classes with CC/UC components of disciplines coincides with the number of academic groups of all EP for which the t-th discipline is taught: $P_{ij} = g_i, j = 2$, where $g_i = \sum_{n=1} g_n^i$.

Moreover, according to the maximum occupancy of academic groups, each academic group of each EP can have no more than 23 students:

$$N_i^y \leq 23. \tag{7}$$

Generating the streams number of practical classes with OC components disciplines.

The streams number of practical classes with OC component disciplines coincides with the number of academic groups of all EP for which the r-th discipline is taught: $P_{rj} = g_r, j = 2$, where $g_r = \sum_{n=1} g_n^r$.

Moreover, the number of students in the stream does not exceed the maximum possible number of students from different EP:

$$\sum_n N_n^{rj} \leq 23, \ j = 2. \tag{8}$$

Generating the streams number of laboratory classes with CC/UC/OC component disciplines.

The number of laboratory streams coincides with the number of academic groups of all educational programs for which the i-th and r-th disciplines are taught: $P_{ij} = g_i, P_{ir} = g_r, \ j = 3$.

Generating the streams number of Office hours with CC/UC/OC components of disciplines.

The student's independent work under the guidance of the teacher is carried out according to the teacher's office hours schedule. The number of streams according to Office hours coincides with the streams number of lecture classes with CC/UC/OC components of the disciplines: $P_{ij} = P_{i1}, P_{rj} = P_{r1}, \ j = 4$.

Criteria for initializing academic groups according to study streams.

1. Maximizing the distribution of classroom fund.

Let L^{Am} be the number of distributed classes of taught disciplines by type of classrooms A_m, Q is the number of classrooms for each type,

$$R = \frac{T_e - T_s}{T} \cdot X = 36 \tag{9}$$

is the amount of using one available classroom for all types during one study week, where T_s is the start time of students' classes (8:00), T_e is the end time of classes (20:00), T is the duration of one type lesson (2 academic hours), X is the number of study days (6: Monday-Saturday),

$$Q^{Am} \cdot R \tag{10}$$

is the amount of using the classroom fund for each type.

Then the maximum distribution of the classroom fund is determined by the objective function:

$$L^{Am} \rightarrow Q^{Am} \cdot R. \tag{11}$$

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2. The maximum available distribution of the students' number in each stream, namely minimizing the deviation of the students' number from the number of distributed available places in the stream, is determined by the following objective function:

$$\left|N_i - \sum_0^{P_{ij}} A_m\right| \to min. \qquad (12)$$

3. Uniform distribution of students across all streams of one discipline, namely, the maximum difference in the classroom fund should be minimal:

$$max\left|A_m^p - A_m^{P_{ij}}\right| \to min, \qquad (13)$$

where $p = \overrightarrow{1, P_{ij}}$ is the serial number of streams of i-type discipline by j-type of academic work.

Thus, the formalized task of generating educational flows for each discipline of each type of academic work will have the following form:

$$P = max\left|P_{ij}^{max} - P_{ij}^{min}\right| \to min, \qquad (14)$$

classroom selection will be calculated using the formula:

$$A_m^p = \sum_{m=1}^{5} A_m^0 \cdot \alpha \cdot \beta \cdot \gamma, \qquad (15)$$

where all criteria for initializing groups by streams are specified by the following functions:

$$\alpha = \begin{cases} 1, & \text{if the condition}(11) \text{ is satisfied}, \\ 0, & \text{otherwise}, \end{cases}$$

$$\beta = \begin{cases} 1, & \text{if the condition}(12) \text{ is satisfied}, \\ 0, & \text{otherwise}, \end{cases} \qquad (16)$$

$$\gamma = \begin{cases} 1, & \text{if the condition}(13) \text{ is satisfied}, \\ 0, & \text{otherwise}. \end{cases}$$

Calculation of the teaching load of academic work.

Let the following loads (number of academic hours) of disciplines be determined according to the WC:

C_{ij} – load for each i-type discipline of the CC/UC component and the j-type of academic work $(i = \overrightarrow{1, q},\ j = \overrightarrow{1, k})$;

C_{rj} – load for each r-type discipline of the OC component and the j-type of academic work $(r = \overrightarrow{1, u},\ j = \overrightarrow{1, k})$.

The number of hours required to conduct an exam in the CC/UC/OC components of the disciplines is calculated by the formulas:

$$C_{ij} = \frac{N_i}{10}, C_{rj} = \frac{N_r}{10},\ \ j = 5. \qquad (17)$$

The load of CC/UC/OC components of disciplines is the number of streams for each type of academic work multiplied by the load for the corresponding type of work in a given discipline: $C_i = \sum_{j=1}^{0} P_{ij} C_{ij}\, , C_r = \sum_{j=1}^{0} P_{rj} C_{rj}$.

Calculation of the teaching load of extracurricular work.

We will define the following types of educational extracurricular work (advising, practice management, supervision of theses/master's theses/doctoral dissertations, membership in the State Attestation Committee): $V_d = \{V_1, V_2, \dots, V_q\}, \quad d = \overrightarrow{1, q}$.

The load of extracurricular types of work is the number of academic groups for each type of extracurricular work, multiplied by the load for the corresponding type of extracurricular work for each educational department:

$$C_d = g_d^h \cdot C_{dj},\ d = \overrightarrow{1,2} \quad j = 5, \tag{18}$$

where $K_h = \{K_1, K_2, \dots, K_t\},\ h = \overrightarrow{1,t}$, is the set of the educational departments/faculties carrying out extracurricular activities for relevant educational programs.

The workload for supervising and defending theses, master's and doctoral dissertations, and working at the State Attestation Commission is calculated depending on the number of students using the following formula:

$$C_d = N_d^h \cdot C_{dj},\ d = \overrightarrow{3,4} \quad j = 5, \tag{19}$$

where the number of students enrolled to the d-th type of extracurricular work: $N_d = \sum_{n=1} N_n^d$.

Thus, the average annual teaching load for the university is calculated using the formula:

$$UL = \sum_{i=1}^{0} C_i + \sum_{r=1}^{0} C_r + \sum_{d=1}^{0} C_d, \tag{20}$$

average annual teaching load for the educational department is:

$$(UL)^h = \sum_{i=1}^{0} C_i^h + \sum_{r=1}^{0} C_r^h + \sum_{d=1}^{0} C_d^h, \tag{21}$$

annually approved by the decision of the Academic Council for the corresponding academic year.

Methods and Materials

Data mining and operations research techniques were used to write the functional model namely measuring teaching load indicators [17], and analysis of both quantitative and qualitative reports [18]. Namely, the methods for finding optimal solutions based on mathematical modeling. Empirical and quantitative methods were used to write a mathematical model. The results of a survey on the enormous influence that the university administration has on the academic community were examined in the work. In this work the survey analysis of teachers and university administration was assessed to optimize the calculation of the educational work volume in the university was taken as empirical methods. The methods of mathematical analysis and discrete mathematics using the number of finite sets with Boolean variables, as well as methods of function approximation were taken as the quantitative methods [16]. The rationale for choosing these methods is a systematic approach to the problem and analysis.

Note that the presented models were tested based on university data in Excel according to the 2023-2024 academic year. The data sample included tables of the working curriculum, the student contingent, the auditor fund and the staffing schedule. Optimization methods, in particular linear programming, were used as methods of operations research in software development. The Python programming language was used to develop the program [19], [20].

Results

The functional and mathematical models and decision support algorithms considered in the work make it possible to optimize the process of solving the distributing problem of educational work volume between educational departments in the university. At the same time, the algorithm makes it possible to create a decision support system for generating educational study streams and initializing academic groups based on the using the human-machine procedures. A mathematical model implemented in the form of a discrete set of equations and systems makes it possible to obtain, according to given criteria and restrictions, a variety of acceptable options for the formation of study streams and groups, as well as calculation of the teaching load of a university, from which the decision maker (department of academic activities) selects the most optimal option distributions. The following achievements were selected as criteria for the optimal formation of study streams and groups: maximizing the distribution of classroom funds; the maximum available distribution of the students number in each stream; uniform distribution of students across all streams of one discipline; minimizing the study streams of each discipline of each type of educational work, taking into account the distribution of all remaining vacant positions and due to the limited classroom fund.

The program for generating educational streams and initializing academic groups was developed (Fig. 5). The testing results in the summary table showed the high efficiency of the models, their compliance with the established criteria, restrictions and a significant reduction in the time for the planning process. The new model showed significant advantages, namely it allowed:

- to reduce labor costs for the process of planning the volume of educational work;
- to minimize the likelihood of errors;
- to optimize the use of teaching potential.

Discipline	Format	Flows number	Flows	Students	Department	Teacher
Calculus 1		20	ОП1-1, ОП1-2, ОП1-3	60	Department 1	teacher name
Calculus 1			ОП1-4, ОП1-5, ОП1-6	60	Department 1	teacher name
Calculus 1			ОП1-7, ОП1-8, ОП1-9	60	Department 1	teacher name
Calculus 1			ОП1-10, ОП1-11, ОП1-12	59	Department 1	teacher name
Calculus 1			ОП1-13, ОП1-14, ОП1-15	60	Department 1	teacher name
Calculus 1			ОП1-16, ОП1-17, ОП1-18	60	Department 1	teacher name
Calculus 1			ОП1-19, ОП1-20, ОП1-21	60	Department 1	teacher name
Calculus 1			ОП1-22, ОП1-23, ОП1-24	59	Department 1	teacher name
Calculus 1			ОП1-25, ОП1-26, ОП1-27	59	Department 1	teacher name
Calculus 1			ОП1-28, ОП1-29, ОП1-30	56	Department 1	teacher name
Calculus 1			ОП1-31 ОП1-32, ОП1-33	57	Department 1	teacher name
Calculus 1			ОП1-34, ОП1-35, ОП1-36	58	Department 1	teacher name
Calculus 1			ОП2-1, ОП2-2, ОП2-3	60	Department 1	teacher name
Calculus 1			ОП2-4, ОП2-5, ОП2-6	60	Department 1	teacher name
Calculus 1			ОП2-7, ОП2-8, ОП2-9	60	Department 1	teacher name
Calculus 1			ОП3-1, ОП3-2, ОП3-3	57	Department 1	teacher name
Calculus 1			ОП3-4, ОП3-5, ОП3-6	55	Department 1	teacher name
Calculus 1			ОП4-1, ОП4-2	40	Department 1	teacher name
Calculus 1			ОП5-1, ОП5-2, ОП1-37	47	Department 1	teacher name
Calculus 1			ОП3-7, ОП6-1, ОП7-1	45	Department 1	teacher name
Cultural Studies	MOOC	5	ОП1-1, ОП1-2, ОП1-3, ОП1-4, ОП1-5	100	Department 2	teacher name
Cultural Studies	MOOC		ОП2-1, ОП2-2, ОП2-3, ОП2-4, ОП2-5	95	Department 2	teacher name
Cultural Studies	MOOC		ОП3-1, ОП3-2, ОП3-3, ОП3-4, ОП3-5	94	Department 2	teacher name
Cultural Studies	MOOC		ОП3-6, ОП3-7, ОП3-8, ОП3-9, ОП2-6	97	Department 2	teacher name
Cultural Studies	MOOC		ОП2-7, ОП1-6, ОП1-7, ОП4-1, ОП5-1	81	Department 2	teacher name

Figure 5. Summary table of the program for generating educational streams and initializing academic groups

The program initializes and seats educational flows of lectures and practical classes of students of all courses in all disciplines, including disciplines of the elective component. One flow may consist of one or several academic groups of one or different educational programs depending on the discipline (general block, mathematical block), discipline component (CC/UC/OC), types of academic work and other criteria.

This approach ensures a fair distribution of the teaching load, as well as the effective use of the potential of educational departments in the interests of its further development.

Discussion

This paper has developed a new methodology for solving complex optimization problems that arise when modeling and optimizing the distribution of the academic work volume at the university. It should be noted that comparative experiments under labor-intensive and time-limited conditions confirm the effectiveness of this technique in solving problems of distributing the amount of educational work across departments of educational programs, which in turn contributed to the implementation of high-quality software. Thus, the resulting algorithm combines the advantages of already existing algorithms, and its use will make it possible to find "optimal" solutions to the problem of generating educational flows in an acceptable time. In addition, the proposed algorithm allows us to qualitatively and rationally solve the problem of finding the best solution, taking into account a number of criteria and restrictions. Next, a functional and mathematical model is created, which served as the basis for the development of special software products for automating business processes for distributing the teaching load at the university. Thus, the problem being solved is considered as a best approximation problem, which reduces to a minimax problem. Moreover, it should be noted that the developed mathematical model is unique, since at the moment there are few presented mathematical models for the distribution of the volume of university educational work. The results of the study can serve as the basis for further research in this area and be useful for the development of a modern education system.

Conclusion

The proposed functional and mathematical models for planning the university's teaching load will allow not only to take into account the tasks that must be completed in a strictly defined period (for example, planning for the next academic year), but also to implement an even distribution of the teaching load during the academic year.

The considered technology served to create automated planning of the volume of educational work of the university, which will significantly reduce time, eliminate errors, and, if necessary, quickly make amendments to the plan of the teaching load of the university.

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References

[1] Ishanov, Ye., & Magauova, A. (2021). Development of information and management competence of the heads of the structural unit of a modern university. *Al-Farabi Kazakh National University*, 68(3), 138–158. https://doi.org/10.26577/JES.2021.v68.i3.12

[2] Saule, K., Indira, U., Aleksander, B., Gulnaz, Z., Zhanl, M., Madina, I., & Györök, G. (2018). Development of the information and analytical system in the control of management of university scientific and educational activities. *Acta PolytechnicaHungarica*, 15(4), 27–44. https://doi.org/10.12700/APH.15.4.2018.4.2

[3] Kargin, D., Merzadinova, G., Safarov, R., & Mahmutov, B. (2021). On the degree of influence of the teaching load on the scientific and innovative activity of scientists using the example of ENU. *Bulletin of L.N. Gumilyov Eurasian National University*, 1(134), 67–73. https://doi org/10.32523/2616-6895-2021-134-1-67-74

[4] Blair, B.L., Slagle, D.R., & Williams, A.M. (2021). Institutional and programmatic determinants for graduate public affairs' online education: Assessing the influence of faculty workload. *Teaching Public Administration*, 40(2), 181-198. https://doi.org/10.1177/01447394211017326 (Original work published 2022)

[5] Kumargazhanova, S., Erulanova, A., Soltan, G., Suleimenova, L., & Zhomartkyzy, G. (2018). System of indicators for monitoring the activities of an educational institution. Proceedings - 2018 Ural

Symposium on Biomedical Engineering, Radioelectronics and Information Technology, USBEREIT, 179–182. https://doi.org/10.1109/USBEREIT.2018.8384580

[6] Nieto, Y., García-Díaz, V., Montenegro, C., & Crespo, R. (2019). Supporting academic decision making at higher educational institutions using machine learning-based algorithms, Soft Computing, 23(12), 4145–4153. https://doi.org/10.1007/s00500-018-3064-6

[7] Vanessa N.Y., Diaz, V.G., & Montenegro, C.E. (2016). Academic decision-making model for higher education institutions using learning analytics. *4th International Symposium on Computational and Business Intelligence, ISCBI,* 27–32. https://doi.org/10.1109/ISCBI.2016.7743255

[8] Rakhmetullina, Z., Soltan, G., Mukasheva, R., Mukhamedova, R., & Tezekpayeva, S. (2021). Functional and architectural solution of a software package for the analysis of educational data. International Congress of Advanced Technology and Engineering, ICOTEN. https://doi.org/10.1109/ICOTEN52080.2021.9493505

[9] Kumargazhanova, S., Soltan, G., Zhomartkyzy, G., & Suleymenova, L. (2019). Analytical monitoring model of educational system.ACM International Conference Proceeding Series, 14, 1-5. https://doi.org/10.1145/3330431.33304

[10] Gaete, M., & González-Araya, M.C. (2024). Assessment of the academic load in a curriculum through an optimization model: case study of a master program. *International Conference on Operations Research and Enterprise Systems*, 269–274. https://doi.org/10.5220/0012365400003639

[11] Soltan, G., Zunimova, G., & Sarsenbayeva, G. (2020). The Algorithm for Designing Competency Oriented Educational Programs Based on the Data Analysis of Academic Processes. Proceedings - 2020 Ural Symposium on Biomedical Engineering, Radioelectronics and Information Technology, USBEREIT, 488–491. https://doi.org/10.1109/USBEREIT48449.2020.9117787

[12] Chigambayeva, D., Goryakin, M., & Batova, P. (2024). Optimization models for teaching load formation of university teachers, *IEEE AITU: Digital Generation*International Conference Proceedings, 146–149. https://doi.org/10.1109/IEEECONF61558.2024.10585368

[13] Markvirer, V.D., & Karnaukhova, E.A. (2023). University Teaching Load Distribution Algorithm. Proceedings of the International Conference "Quality Management, Transport and Information Security, Information Technologies", IT and QM and IS 2023,152–155. https://doi.org/10.1109/ITQMTIS58985.2023.10346285

[14] Gaete, M., & González-Araya, M.C. (2024). Assessment of the Academic Load in a Curriculum Through an Optimization Model: Case Study of a Master Program. *ICORES*, 269-276. https://doi.org/10.5220/0012365400003639

[15] Muniandy, N., Ishak, R., & Abd Rahim, N. (2021). Linear programming subject allocation model for private school teachers. Open International Journal of Informatics, 9(Special Issue 2), 50-57. https://www.researchgate.net/publication/357168840

[16] Awang, N., & Jamian, N.H. (2020). The department team teaching assignment problem using zero-one integer programming. *Journal of computing research and innovation*, *5*(1), 1-7. https://doi.org/10.24191/jcrinn.v5i1.156

[17] Mushabe, C., Abreh, M., & Mills, C. (2022). Reconceptualizing faculty workload as a measure of human resource motivation and performance in higher education. *Social Sciences & Humanities Open*, 6(1), https://doi.org/10.1016/j.ssaho.2022.100279

[18] Stacey, M., McGrath-Champ, S. & Wilson, R. (2023). Teacher attributions of workload increase in public sector schools: Reflections on change and policy development. *J Educ Change,* 24, 971–993. https://doi.org/10.1007/s10833-022-09476-0

[19] NA, L.A., & HUSSIN, M.S. (2021). Course Allocation Among Lecturers Using Python. *Universiti Malaysia Terengganu Journal of Undergraduate Research*, *3*(4), 127-136. https://doi.org/10.46754/umtjur.v3i4.246

[20] Bogdanchikov, A., Zhaparov, M., & Suliyev, R. (2013, April). Python to learn programming. In *Journal of Physics: Conference Series* (Vol. 423, No. 1, p. 012027). IOP Publishing. https://doi.org/10.1088/1742-6596/423/1/012027