7. Данилов А. Д. Процессный подход MOF и MICROSOFT SHAREPOINT как путь к повышению качества ИТ-услуг [Электронный ресурс] / А. Д. Данилов, А. Н. Боровцов. Режим доступа: https://cyberleninka.ru/article/n/protsessnyy-podhod-mof-i-microsoft-sharepoint-kak-put-k-povysheniyu-kachestva-it-uslug.

8. Elektron resurs [Электронный ресурс]. Режим доступа: https://infowatch.com/company.

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DEVELOPMENT OF MATHEMATICAL MODEL OF LESSON SCHEDULE FORMATION SYSTEM

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Abstract. *The article presents the task of creating a linear mathematical model and an algorithm for automatically constructing a table of studies in a higher educational institution.*

Keywords: *Higher education institution, mathematical model, linear programming, course schedule, resource, objective function.*

Аннотация. *Представлена задача создания линейной математической модели и алгоритма автоматического построения таблицы учебных занятий в высшем образовательном заведении.*

Ключевые слова: *высшее учебное заведение, математическая модель, линейное программирование, расписание курсов, ресурс, целевая функция.*

Introduction. The aim of the provided work is to effectively address the issue of formulating the lesson plan (in the level of defined period and optimality) in a Higher Educational Institution (HEI) and to develop a mathematical model (imperceptible changes in the condition of ingoing change of variables) that has flexibility to adapt the system within concrete practical task.

The quality of training in Higher Educational establishments and, in particular the effectiveness of using scientific and pedagogical potential depends on the degree of organization of the academic process.

One of the main components of this process is the schedule of lessons - regulating the work timeline, affecting teachers' creative usefulness, therefore limited work resources can be considered as a factor in optimizing the use of teachers. The technology of developing the schedule can be considered as an optimal equation of action, not only as a professional technical process, but also as a mechanization of using computer and automation object. Thus, this is a matter of developing an explicit, cost-effective optimal schedule of disciplines for Higher Education Institutions. Creating a lesson schedule has multiple criteria.

It is not necessary to consider the matter of scheduling as a specific program that introduces the function of mechanical distribution of training sessions at the beginning of the semester. The economic benefit of the more efficient use of human resources can only be achieved through careful management of this labor resource. Where the table is a tool for such management, the program should incorporate not only optimal table builders, but also possess means of supporting optimality as a result of changes in some ingoing information that is permanently considered during the course design. In addition, optimal management of such a complex system can not be optimally adjusted without collecting statistical information about processes that occur in the system. Therefore, the problem of creating an optimal table is itself just a part of the complex system of learning process management [1–3].

The criteria of this matter and the complexity of the object for which mathematical model is being built need for consistent mathematical study of the object to increase the functional capacity of the lesson scheduling without increasing the complexity of the model and increasing the amount of memory and time used to solve the problem.

Illumination of the matter. The problem of the theory of development of lesson schedule is very presentable, though it is difficult to find a solution for its overall design. Although many qualified specialists have been trained in the theory of course schedules, no one has achieved perceptible achievements so far. Failing attempts to obtain such results were not usually published, and this explains the reason why many researchers are attracted to a seemingly simple posture.

Generally, creating a lesson schedule is the following. With a specific set of resources or service providers, a specific system of tasks must be implemented. Finding an effective algorithm for sorting out tasks that optimize or intended to optimize the required productivity standards based on the specifications, objectives and resources provided and the limitations imposed on them. The main measurements of efficiency are the number of columns and rows of tables, and the average time to obtain a solution.

In the general theory of the course schedules, all service providers (or processors) can no longer perform more than one function. Therefore, when assuming the general lesson theory into the lesson schedule, the following assumptions were made [4–5]:

- every processor (that is, in the case of study schedule - auditorium) has a the capacity, specific $c \geq 1$ number. The capacity of the processor determines the number of simultaneous tasks that can be processed at the same time (the processor is not an auditorium not as a unique, but as a teacher serving and as a task, it is also interesting to look at the potential of one or more study groups working alone);
- provides training sessions with teacher training groups as a set of distribution tasks;
- time model in the system is discrete; all distributions are assumed to be sequential repetitions within a certain period of time;
- all the tasks are accepted at the same time, and it is considered as a time interval discrete unit;
- the tasks belong to the objects of the training groups and the teacher's personality.

As a result, the description of how to create a training schedule has the following criteria: "The given set of educational auditoriums (in this case when speaking about educational auditorium wide facilities (from computer auditoriums to sport facilities) where educational trainings are held are normally understood and observation of educational training distribution for all objects (teachers and training groups) that have the best optimal criteria in a given period of time (on the content of study or educational pairs)".

Mathematical model of lesson schedule formation in Higher Educational Institutions (HEI). We come across linear programming terms of mathematical model of lesson schedule in Higher Educational Institutions. By entering definitions we will define variables and limitations.

In HEI there are N training groups that was joined to R whole group; r-number of the whole group, $r = 1, \dots, R$, $k_r - r$ number of the training group in the whole group, $k_r = 1, \dots, G_r$.

Group and subdivision of the group are based on the following principles:

1. The use of a single audience for lectures by two groups assumes that they will automatically be placed in one whole group (all lectures of the training groups are conducted together).

2. The group (or its part) can be divided into different capacities as a unit of learning process at the University, but each one may have one.

3. The number of the whole group is not limited.

Classes are held during workdays, between one and a half hours called a pair.

Denotation:

t – number of the workday of the week, t^{TM} $T_{kr,}$ here;

T_{kr} – k_r collection of numbers of the workdays for the group;

j – number of the pair, $j = 1, \dots, J;$

J – number of general pairs.

According to the curriculum W_{kr} training is conducted with each k_r training groups of the R whole group, out of them S_r is lecture and Q_{kr} is practical.

Denotation:

s_r – r number of the subjects in the list of lecture texts for the group, $s_r = 1, \dots, S_r$;

q_{kr} – k_r – number of the subject in the list of practical training for the group, $q_{kr} = 1, \dots, Q_{kr}$.

It is assumed that all lectures are conducted simultaneously in all groups of the whole group and in one auditorium. If more than one lesson is conducted on a particular subject during the week, the subject is recorded as many times by the group's lesson plan in the list of lectures or practical exercises.

p – number of the teacher (name), $p = 1, \dots, P$, $\delta^p_{rS_r}$ and $\Delta^p_{rk_rq_{kr}}$.

We will put the following values:

$\delta^p_{rS_r} = \Big\{$ 1, If in r group s_r the lecture is read by p teacher; 0 – in such case;

$\Delta^p_{rk_rq_{kr}} = \Big\{$ 1, If in k_r group q_{kr} practical training is read by p teacher.

The teachers' training task is planned until the course schedule is done, as a result in this stage $\delta^p_{rS_r}$ and $\Delta^p_{rk_rq_{kr}}$ dimensions can be considered to be given. For each p teacher $(p = 1, \dots, P)$ Auditorial load N_p hour is given for each week.

Training of each group can only be conducted in a particular auditorium (for example: practical trainings on computer science can only be conducted in display classes):

$\{A_{1r}\}$ in r – group auditorium collection for lectures;

$\{A_{2r}\}$ in r – group auditorium collection for practical trainings;

A_{1r} … – $\{A_{1r}\}$ – number of elements of collection;

A_{2r} … – $\{A_{2r}\}$ – number of elements of collection;

$A_{1r\,+}\,A_{2r}$ – $\{A_{1r}\}$ $\{A_{2r}\}$ – auditorium number of collection.

The auditoria fund is determined before the schedule is created, therefore the bundle can be considered as given.

The issue of scheduling is to identify a specific target function for each lecture (in the whole group) and practical exercise, and to determine days of the week and pairs taking into account whether the limitations are set.

Searched changes determined as follows:

$y^{s_r}_{rt_j} = \Big\{$ 1, If in r group on t day in j pair s_r lecture is read; 0 – in such case;

$x^{q_{kr}}_{rk_rt_j} = \Big\{$ 1, If in r group on t day in j pair q_{kr} practical training is conducted; 0 – in such case

Limitations:

During the week for each k_r group, all auditorial works should be done:

$$\sum_{t\in T_{kr}}\sum_{j=1}^{J}\left(\sum_{q_{kr}=1}^{Q_{kr}} x^{q_{kr}}_{rk_rt_j} + \sum_{s_r=1}^{S_r} y^{s_r}_{rt_j}\right) = W_{kr}$$

$$\forall r = 1,\dots,R; \forall k_r = 1,\dots\dots$$

On optional t day in each j pair for each k_r group, more than one lesson can be conducted:

$$\sum_{q_{kr}}^{Q_{kr}} x^{q_{kr}}_{rk_rt_j} + \sum_{s_r}^{S_r} y^{s_r}_{rt_j} \le 1$$

$$\forall r = 1,\dots,R;\ \forall k_r = 1,\dots,G_r;\ \forall t \in T_k;\ \nabla j = 1,\dots,J$$

Accordingly, each s_r lecture and q_{kr} practical training for all whole r groups and small k_r groups can not be conducted more than once on a t particular day:

$$\sum_{t\in T_{kr}}\sum_{j=1}^{J}\left(x^{q_{kr}}_{rk_rt_j} + y^{s_r}_{rt_j}\right) \le 1$$

$$\forall r = 1,\dots,R;\ \forall k_r = 1,\dots,G_r;\ \forall t \in T_k;\ \forall j = 1,\dots,J$$

$$\forall s_r = 1,\dots,S_r;\ \forall q_k = 1,\dots,Q_k$$

If $x^{q_k}_{r k_r t_j}$ and $y^{S_r}_{r t_j}$ can handle all types of training sessions with their timing, then $\Delta^{p}_{r k_r q_k} \cdot x^{q_k}_{r k_r t_j}$ and $\delta^{p}_{r s_r} \cdot y^{S_r}_{r t_j}$ connect the teacher's name with the time of multiplication.

Every t day and in each j pair p teacher may have no more than one lesson on one subject area in one whole group or in one small group:

$$\sum_{r=1}^{R}\left(\sum_{s_r}^{S_r}\delta^{p}_{r s_r} y^{s_r}_{r s_r} + \sum_{k_r=1}^{G_r}\sum_{q_{kr}=1}^{Q_{kr}}\Delta^{p}_{r k_r q_{kr}} \cdot x^{q_{kr}}_{r k_r t_j}\right) \le 1$$

$$\forall t \in T_k;\ \forall j = 1,\dots,J;\ \forall p = 1,\dots,P.$$

Each *p* teacher must conduct auditorial trainings during the week:

$$\sum_{t \in T_{kr}}\sum_{j=1}^{J}\sum_{r=1}^{R}\left(\sum_{s_r=1}^{S_r}\delta^{p}_{r s_r} y^{s_r}_{r s_r} + \sum_{k_r=1}^{G_r}\sum_{q_{kr}=1}^{Q_{kr}}\Delta^{p}_{r k_r q_{kr}} \cdot x^{q_{kr}}_{r k_r t_j}\right) = N_p$$

$$\forall p = 1$$

Finally, the number of lectures and practical trainings per day in each pair must not exceed the auditorium fund that has at the Higher Education Institution:

$$\sum_{s_r=1}^{S_r} y^{s_r}_{r t_j} \le A_{1r}$$

$$\forall t \in T_k;\ \forall j = 1,\dots,J.$$

$$\sum_{k_r=1}^{G_r}\sum_{q_{kr}=1}^{Q_{kr}} x^{q_{kr}}_{r k_{r} t_j} \le A_{2r}$$

$$\forall r = 1,\dots,R;\ \ \forall t \in T_k;\ \forall j = 1,\dots,J$$

Additionally, all intersecting $\{A_{1r}\}$ and $\{A_{2r}\}$ bundles require the following condition:

$$\sum_{s_{r_{i1}}=1}^{S_{r_{i1}}} y^{s_{r_{i1}}}_{r_{i1} t_j} + \dots + \sum_{s_{r_{in}}=1}^{S_{r_{in}}} y^{s_{r_{in}}}_{r_{in} t_j} + \sum_{k_{r_I}=1}^{G_{r_I}}\sum_{q_{k r_I}=1}^{Q_{k r_I}} x^{q_{k r_I}}_{r k_{r_I} t_j}$$

$$\sum_{k_{r_I}=1}^{G_{r_I}}\sum_{q_{k r_I}=1}^{Q_{k r_I}} x^{q_{k r_I}}_{r k_{r_I} t_j} \le A_{1 r_{i1}} + \dots + A_{1 r_{in}} + \dots + A_{2 r_I} + \dots + A_{2 r_m}$$

The unconditional restrictions that may be taken into account when forming up a schedule of mentioned relation are completely over. Special conditions, for example, specific type of work on "high" and "low" weeks (namely, one academic hour in per week) can be conducted. Other special conditions can also exist, but they are not observed to simplify the model.

Function of purpose. There should be a leisure time for a university (HEI) teacher to complete scientific, educational and methodological work and to prepare for the training. The leisure time should not be like as free time period between pairs (so called «window), but there should be available free full working days, if possible. This is equivalent to maximizing teachers' auditoria load on days when they possess it (see also 6). However, claims for free time are not equal, because they have different creative potentials. Therefore, it is necessary to include such weighting coefficient, on the basis of which the teacher's position - his academic degree and rank, his / her position, his / her scientific social activeness and so on should be taken into consideration. In some cases, on the basis of experimental estimates, it is necessary to use individual weight coefficients taking into account other factors.

Thus, we select the quality of training schedule for all teachers in the form of maximizing the number of days that are missing from the auditorium work, which is equivalent to the maximum concentration of the auditoria load as long as the length of the working week.

For the size of the auditoria load of the *P* teacher's *t* day, we will look at the following expression:

$$Q^{p}_{t} = \sum_{r=1}^{R}\left(\sum_{s_r=1}^{S_r}\delta^{p}_{r s_r} \cdot y^{s_r}_{r t_j} + \sum_{k_r=1}^{G_r}\sum_{q_{kr}=1}^{Q_{kr}}\Delta^{p}_{r k_r q_{kr}} \cdot x^{q_{kr}}_{r k_r t_j}\right)$$

The following limitations are applied:

$$1 \le Q^{p}_{t} + M^{Z^{p}_{t}} \le M \quad \forall t \in T_{kr};\ \forall p = 1,\dots,P.$$

Here M is a sufficiently enough large number in the degree of option; - searchable bull variable.

If it is from (11) $Q^{p}_{t} = 0$, in such case $z^{p}_{t} = 1$, and If $Q^{p}_{t} > 0$, in such case $z^{p}_{t} = 0$

Taking into consideration the content of the above-mentioned optimization criterion (11) and the Ω_p weighting factor of teacher rank, we are looking at the criteria for optimism:

$$\sum_{t \in T_{kr}}\sum_{p=1}^{P}\Omega_p z^{p}_{t} \to max.$$

The target function that was entered is not unique. Adding other target functions does not modify mathematical model constraints and problem solving, but can have a significant impact on the calculation results.

Developing software of the matter. The information needed to resolve the issue is given prior to the iteration of the methods of addressing the issue of the class scheduling. In order to simplify, given information will remain unchanged throughout the whole period. Without losing a certain level of totality of the issue, it is possible to define a set of unwanted variables that are required for constraining and solving problems, and also commonly used for all system applications. The forms of incoming information documents have not been developed yet due to the specific nature of the issue (the possibility of relatively easy adaptation of the mathematical model to practical application within a specific HEI). The details of the incoming information are described in the table.

Developing software of the matter. The current information is analyzed to determine the content and structure of information for the establishment and formulation of an informative and logical model of information (LMI). The above-mentioned mathematical model and additional information from the description of the science domain allows to identify the role of the requisites in the linked information stored in the document. On the basis of this analysis, it is possible to establish functional links in line with the data normalization requirements and according to that requirements, and then we will normalize them. The purpose of normalization is to reduce the amount of data (but not to erase). However, at times, a certain amount of data is created deliberately to maximize the effectiveness of the software.

Conclusion. During the research process, models for the optimization and forecasting of students' learning in the formation of lesson schedule were suggested. For the first time, these models were resolved by means of neurovascular approximation. In this work a common approach to addressing multidimensional issues with unclear linear programming with unclear coefficients. The generalizing principle of this approach is the concept of unclear relation, particularly the relation of equality or inequality and the notion of operator of aggregation.

The problem of unclear linear programming has been presented, a reasonable solution has been identified, the problem of "alternative" solution counting towards unclear linear programming matter was reviewed. Two approaches were suggested: the former approach is based on a satisfactory solution, based on external goals modeled with unclear measurements; and the latter is based on α - effective (non-prior) solution. Further research focuses on the secondary unclear programming.

Finally, many criteria have been addressed, and many unclear linear programming problems have been described. Once a solution has been identified, the conclusions of bringing the problem to such solutions of non-linear equivalents have been summed up.

An original software was created for the purpose of optimization and prediction matters by the help of models. An impolitic suggestion on the organization of the learning process and maintaining a student contingent in higher education institutions. Has been developed. Data base structure and scheme of the processes were given in it.

References

1. *Zadeh L. A. Fuzzy sets / L. A. Zadeh // Information and control. 1965. Vol. 8. P. 338–353.*
2. *Aliev R. A. The theory of intelligent systems / R. A. Aliev, R. R. Aliev. Baku: Publishing House "Chashyolgy", 2001. 720 p.*
3. *Mukhamedieva D. T. Evolutionary algorithms for solving multicriteria optimization problems / D. T. Mukhamedieva // Publishing house "Palmarium Academic Publishing". AV Akademikerverlag GmbH & Co.KG Heinrich-Böcking-Str. 6–8, 66121 Saarbrucken, Germany. 2015. 262 p.*
4. *Bekmuratov T. F. Fuzzy-multiple models of adoption of weakly structured solutions / T. F. Bekmuratov, D. T. Mukhamedieva // Publishing house "Palmarium Academic Publishing". AV Akademikerverlag GmbH & Co.KG Heinrich-Böcking-Str. 6-8, 66121 Saarbrucken, Germany. 2015. 172 p.*
5. *Mukhamedieva D. T., Primova Kh. A. Approach to problem solving multicriterial optimization with fuzzy aim / D. T. Mukhamedieva, Kh. A. Primova // International Journal of Mathematics and Computer Applications Research (IJMCAR). USA, 2014. Vol. 4, Issue 2, P. 55–68.*