Methodology of Formation of the Individual Study Plan of the Student Based on the Graph Model of the Dependence of Disciplines

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Abstract

The article considers the problem of forming a personalized study plan for a student in accordance with his academic performance. It is noted that currently, students choose elective subjects at random, based on the principle of mass or a certain "curiosity". It is proposed to develop a method of forming an individual study plan for each individual student, taking as a basis performance indicators for previously studied disciplines. Thus, using the indicated method to form a student's individual educational plan, a higher educational institution will be able to form high-quality specialists, relying on their personal skills and educational achievements.

Keywords

Indicated method, Individual Study Plan, High-Quality Specialists, Personal Skills, Educational Achievements

1. Introduction

Higher education in various countries has developed rapidly over time. In order to improve the education of their students, universities changed the teaching methodology, selected a convenient number of subjects and derived the optimal study time for each discipline.

Considering the events of recent years in the world, in particular with the spread of the COVID-19 pandemic [1], there is an urgent need to improve distance education. Considering the realities of today's Ukrainian student, education was also forced to stand on the rails of "war" and adapt to new challenges. In order to improve the education of their students, universities began to change teaching methods, select a convenient number of subjects and adapt the teaching of material for maximum effect in minimum time within each discipline. In most modern universities, there are different types of teaching methods, from remote to selective form, thereby giving students the opportunity to develop in the direction in which they see themselves best. Thus, they do not limit themselves in terms of time, as they can choose a convenient time for the couple or in choosing the academic disciplines they wish to study.

The main idea behind the development of the software system is to create a personalized study plan for the student according to his performance. In this way, the university will train first-class and highly specialized professionals, which are so needed in our time. All this will take place with the help of an algorithm, which will monitor the success of each student and, in accordance with the success of previously studied disciplines, will build the most optimal educational plan for the next academic period.

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2. Related works

Higher education in different countries and even universities has developed rapidly over time. In order to improve the education of their students, universities changed the teaching methodology, selected a convenient number of subjects and derived the optimal study time for each discipline. Speaking about the latter, we want to understand that the student who is studying will get the right amount of knowledge that will be needed in his future profession. There are different types of methods of choosing elective subjects and now we will consider it.

Consider the education system of the United States of America. Higher education institutions in this country have a very flexible curriculum. A student can independently choose the time when he wants to study, in particular evening or morning hours, choose the form of education - face-to-face, part-time or distance learning - and there is even such a term as "university without walls". However, the most important thing in a student's choice about his studies is the choice of disciplines at his own will [2]. To choose electives, you must earn a certain number of credits to be able to choose a subject from the list. However, subordination in the proportionality of professional disciplines and disciplines of free choice must be observed in order to develop the professional quality of the specialist.

If we consider the system of higher education in Germany, we will notice certain differences. Due to the recent events in the world, the COVID-19 virus, there was a need for a distance learning system - this is where the main feature emerged.

In German educational institutions, there is a new education system that allows you to study at home. However, this is not the last mission of this product. Thanks to the Stud.ip software system, students have the opportunity through their personal account to view pairs online and lecture recordings, the opportunity to choose their own study schedule and contact teachers directly.

The method of choosing disciplines in this country is implemented through a personalized office of the university, where a student will be able to choose not only a set of disciplines he wants to study, but also teachers, lecturers, personally draw up a schedule of classes and communicate with potential employers [3].

Speaking for Ukraine, the scheme here is quite simple. Students choose from a selected list of disciplines that they like. As in any university, there is a list of professional disciplines that must be read in the course, as well as optional professional and free cycles.

According to the Law of Ukraine "On Higher Education" (Article 62), persons studying in institutions of higher education have the right to choose academic disciplines within the limits provided for by the relevant educational program and curriculum, in the amount of at least 25% of the total number of ECTS credits determined for a certain level of higher education [4].

Ukrainian higher education institutions use the ECTS system. ECTS, or the European Credit Transfer and Accumulation System, is a system that was created to ensure a unified interstate training evaluation procedure, a system for measuring and comparing learning outcomes, their academic recognition and transfer from one educational institution to another.

Let's consider the procedure for choosing disciplines at WUNU (Western Ukrainian National University). On the basis of curricula, the departments form lists of optional academic disciplines that can be submitted for the next academic year. Students, in turn, receive a list and make a choice in the form of writing an application at the department of the university to which they are assigned, or having access to the electronic system "eUniversity" by logging in there as a student, and choosing the list of proposed disciplines. Based on the majority of submitted applications or votes left in the "eUniversity" system, a certain number of optional disciplines is selected for the next academic year.

Summarizing the above, we can say the following - "The error of any choice is the choice itself." That is, sometimes we ourselves do not realize, or we do not have enough data and facts to make a successful choice for ourselves.

3. Overview of the Research

Due to the fact that the majority of students randomly choose elective disciplines of a professional type, it is proposed to automate this system, namely:

- professional disciplines remain mandatory;

- students will be able to choose elective subjects of the free type at their own will;
- selective disciplines of the professional type will be formed on the basis of the method of forming the individual study plan of the student.

The specified method will work on the basis of a constructed graph with the ratio of compulsory subjects of the professional cycle and optional subjects. That is, with the help of the specified method, we will be able to make a personalized schedule of subjects for each student [5]. Thus, the higher educational institution will be able to form high-quality specialists, relying on their personal skills and educational achievements. This method not only optimizes the choice of disciplines and the selection of the curriculum, but also facilitates the study of higher education students.

4. Proposed method

As a graph model [6-8] of the dependence of the disciplines of the professional cycle of the student's curriculum, consider an oriented graph $G(T, A)$, where $T = \{t_i, i = 0..N\}$ – set of graph tops, $A = \{a_{ij}, i = 0..N,\ j = 0..J\}$ – set of graph arcs. The dependence graph of the disciplines of the professional cycle of the student's curriculum $G(T, A)$ is built on the basis of both normative and selective disciplines. The set of tops T of the graph are all normative and selective disciplines of the student's professional training cycle. The set of arcs A reflects the connection between the disciplines, i.e., if there is a transition from the i-th top (discipline) to the j-th top (discipline), then the graph $G(T, A)$ contains an arc a_{ij} that connects these two tops.

When modeling the computing process on a graph model, it is assumed that each element of the model - a top and an arc - is assigned a certain weight [9-11]. Let's assume that each top t_i is characterized by an elementary indicator m_i that is directly related to the student's success, that is, the credit (examination) score given for passing the corresponding i - th discipline. Some tops of the graph will have the indicated indicator $m_i = 0$, because not all disciplines of the elective cycle will be assigned to the student's individual study plan. The entered indicators form a set $M = \{m_i\}$ on the graph.

In turn, each arc a_{ij} which connects the tops t_i and t_j is characterized by a certain weight, in particular, the weight coefficient $k(i, j)$. The specified weight factor is set for each arc in the range from 0 to 1. Given that each top t_i of the graph is a directly specific discipline, normative or selective, the value of the weight factor $k(i, j)$ will be determined by the conditional influence of the results of mastering the discipline of the top t_i, which is measured by the indicator m_i on the discipline of the selective cycle that contained in the top t_j.

All weighting factors form a set $K = \{k(i, j)\}$ on the graph.

The thus built graph model of the dependence of the disciplines of the professional cycle of the student's curriculum is an acyclic oriented loaded graph $G(T, A, M, K)$.

The power of the set M ($|M|$) is determined by the total number of subjects of the professional cycle of education - normative and selective [12].

For the convenience of entering, editing and changing the weights of the arcs of the graph, which may be caused by the clarification of educational plans or the introduction of new disciplines, it is advisable to present this indicator in matrix form. So, the weighting coefficients $k(i, j)$ of the graph model $G(T, A, M, K)$ are represented by a matrix K_{Con} of dimension $L \times N$, where N is the number of all subjects of the professional cycle of education, and L is the number of only selective subjects of the second, third and fourth courses of study.

The matrix $K_{Con}(G) = (k_{ij})_{i=\overline{1..N},\ j=\overline{1..L}}$ is a loaded adjacency matrix in which:

$$k_{ij} = \begin{cases} k(i, j), & if\ a_{ij} \in A, \\ 0, & if\ a_{ij} \notin A. \end{cases} \quad (1)$$

For a loaded adjacency matrix $K_{Con}(G) = (k_{ij})_{i=\overline{1..N},\, j=\overline{1..L}}$, the following condition must be fulfilled:

$$\sum_{i=1}^{N} k_{i1} = \sum_{i=1}^{N} k_{i2} = \ldots = \sum_{i=1}^{N} k_{il} = 1,\ j = 1..L,\ L \subset N. \tag{2}$$

Consider a matrix G_{KM} whose elements are products $k_{ij} \times m_i,\ i = 1..N,\ j = 1..L.$

$$G_{KM} = \begin{pmatrix} k_{11} \times m_1 & k_{12} \times m_1 & \ldots & k_{1l} \times m_1 \\ k_{21} \times m_2 & k_{22} \times m_2 & \ldots & k_{2l} \times m_2 \\ \ldots & \ldots & \ldots & \ldots \\ k_{n1} \times m_n & k_{n2} \times m_n & \ldots & k_{nl} \times m_n \end{pmatrix} \tag{3}$$

The next step is the formation of the set of "significance" S_{rait} of each selective discipline for an individual student according to the formula:

$$S_{rait} = \left\{ \sum_{i=1}^{N} G_{KM_{ij}},\ j = 1..N \right\} \tag{4}$$

The set S_{rait} consists of the rating evaluations of optional subjects of three courses - the second, third and fourth. However, if for the second year we can immediately choose from the set S_{rait} of maximum ratings of specific disciplines, then for the third it will be necessary to wait one year of study and accordingly for the fourth - another year of study. Since the student's individual study plan is built step by step after the end of each academic year.

Therefore, there are two ways to solve this situation:

1. After each academic year, update the matrix G_{KM} and the set S_{rait} and act only in the ranges of values allocated for a certain academic year.
2. After forming the loaded graph $G(T, A, M, K)$ of the dependence of the disciplines of the professional cycle of the student's curriculum, immediately decompose it, i.e. construct three subgraphs [13] $G_1 \subset G$, $G_2 \subset G$ and $G_3 \subset G$ according to the order of the student's academic year. For each formed subgraph, we form the corresponding adjacency matrix $G_{KM_1} \subset G_{KM}$, $G_{KM_2} \subset G_{KM}$ and $G_{KM_3} \subset G_{KM}$ and the significance set $S_{rait_1} \subset S_{rait}$, $S_{rait_2} \subset S_{rait}$ and $S_{rait_3} \subset S_{rait}$.

The next step in the implementation of the method is the selection X subjects from the significance set with the maximum value. The number of disciplines for each year of study can be the same or set manually by the coordinator. The specified number can be specified immediately or specified directly in the year of formation of a new branch of the student's individual study plan.

That is, to determine the set of elective subjects for the second year of study, we can match each student with a set ordered in descending order:

$$S'_{rait_1} = SORT\left(\left\{S_{rait_1}\right\}\right) \tag{5}$$

where the operator $SORT(\bullet)$ arranges the elements of the set in descending order.

The first X disciplines from the ordered set S'_{rait_1} will be included in the student's individual study plan, the rest are simply zeroed out.

Now let's move on to modeling the method of building an individual student plan. As you know, the university has professional disciplines that are necessarily included in the curriculum, and optional ones that the student chooses on his own.

In order to combine the student's previous success and the choice of further disciplines, it is suggested to develop a system of interrelationship of normative and selective disciplines due to the percentage ratio. These percentages will be calculated based on the student's overall performance for the course completed.

For visual perception, with the help of Figure 1, a graphic and with the help of Figure 2, we provide a tabular representation of the specified interrelationship of disciplines for first-year students when choosing second-year disciplines.

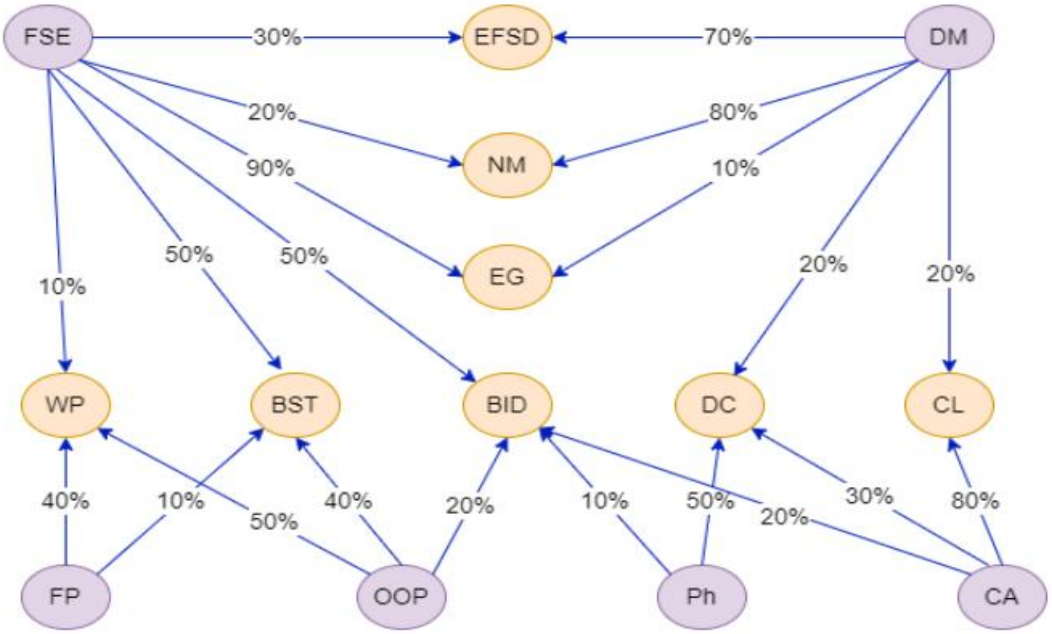


Figure 1: Graph of dependencies of disciplines in the first year

In order to form the curriculum for the second year, we will add optional subjects to professional subjects. Now, the choice of elective course subjects will be influenced by the elective subjects of the previous academic year. That is, now we get the following table of coefficients (see Fig. 3).

We complete the modeling process by forming selective disciplines for the fourth year of study. The algorithm is identical to the previous step: optional subjects of the previous academic year are added to the normative subjects of the current period and affect the choice of subjects for the fourth year.

		Elective disciplines							
№	Coefficient (percentage of success)	DC	WP	BST	NM	CL	BID	EG	EFSD
Normative discipline	Fundamentals of programming	0	0.4	0.1	0	0	0	0	0
	Object-oriented programming	0	0.5	0.4	0	0	0.2	0	0
	Fundamentals of software engineering	0	0.1	0.5	0.2	0	0.5	0.9	0.3
	Computer architecture	0.3	0	0	0	0.8	0.2	0	0
	Discrete Math	0.2	0	0	0.8	0.2	0	0.1	0.7
	Physics	0.5	0	0	0	0	0.1	0	0
	Total	1	1	1	1	1	1	1	1

Figure 2: Coefficients of dependence of disciplines in the first year

		Elective disciplines											
№	Coefficient (percentage of success)	MSDP	PMP	SAI	ML	CSAI	ES	DMSN	WCS	BCT	IS	DS	OGNS
Normative discipline	System analysis	0	0	0	0	0.1	0.3	0	0.1	0.1	0	0	0.1
	Requirements analysis	0	0	0	0	0	0.3	0	0.1	0.1	0.1	0.1	0
	Database design	0.1	0.1	0	0	0	0	0	0	0.1	0.1	0.3	0.1
	Object-oriented programming	0.1	0.1	0	0.1	0	0	0	0	0.2	0.2	0	0
	Algorithms and data structures	0.3	0.4	0.1	0.1	0.1	0	0.2	0.2	0.2	0.2	0.3	0.2
	Operating Systems	0.2	0.1	0.2	0.1	0.1	0	0.2	0.1	0	0	0	0.2
	Higher mathematics	0	0	0.1	0.1	0.1	0.1	0	0	0	0.1	0	0
Selective from the 1st year	Digital circuitry	0	0.1	0.2	0.1	0.2	0	0.2	0.2	0	0	0	0.1
	Web programming	0.2	0	0	0	0	0	0	0	0.1	0	0	0.1
	Basics of Smart technologies	0.1	0.1	0	0.1	0	0	0	0	0.1	0.1	0	0
	Numerical Methods	0	0	0.1	0.2	0.1	0.2	0	0	0	0.1	0.1	0
	Computer logic	0	0	0.2	0.2	0.2	0	0.1	0.1	0	0.1	0.1	0.1
	Basics of interaction design	0	0.1	0.1	0	0.1	0	0.2	0.1	0.1	0	0.1	0.1
	Engineering graphics	0	0	0	0	0	0	0.1	0.1	0	0	0	0
	Economic foundations of software development	0	0	0	0	0	0.1	0	0	0	0	0	0
	Total	1	1	1	1	1	1	1	1	1	1	1	1

Figure 3: Coefficients of dependence of disciplines in the second year

		Elective disciplines											
№	Coefficient (percentage of success)	IT	GT	ESM	DCM	CG	BST	DPES	CC	HMI	CIS	DTS	DSFPGA
Normative discipline	Database programming tools	0.1	0.1	0	0.2	0	0.1	0.1	0	0	0	0.3	0
	Organization of computer networks	0.1	0.1	0	0	0	0.1	0.2	0.1	0.1	0.1	0.1	0
	Professional practice	0.1	0	0.3	0	0.1	0	0	0	0.1	0	0	0
	Software testing quality	0.1	0	0.1	0.2	0.3	0.1	0	0.1	0	0	0.1	0
	Software modeling and analysis	0	0	0	0	0.2	0	0	0	0	0	0	0
	Programming of cyber-physical systems	0.1	0	0.1	0.1	0	0.1	0.1	0.1	0.1	0.2	0.1	0.1
	Software design	0	0	0	0	0.1	0.1	0	0	0	0.1	0	0.2
Selective from the 2nd year	Modern software development platforms	0.1	0.1	0	0	0.1	0.1	0.1	0	0	0.2	0	0.2
	Programming of mobile platforms	0.1	0.1	0	0	0.2	0	0	0	0	0	0	0
	The structure of artificial intelligence	0	0	0	0	0	0	0.1	0.1	0.2	0	0	0.1
	Machine learning	0	0	0.1	0	0	0	0.1	0.1	0.2	0.2	0	0.1
	Computer systems of artificial intelligence	0	0	0	0	0	0	0	0.1	0	0	0	0.1
	Economics of software	0	0	0.4	0	0	0	0	0	0	0	0	0
	Design of multi-service networks	0	0.2	0	0	0	0	0	0	0	0	0	0
	Wireless communication systems	0	0.1	0	0	0	0.1	0.1	0.1	0.1	0.1	0	0.1
	Basics of cloud technologies	0.1	0	0	0	0	0.2	0	0	0.1	0	0	0
	Informational security	0.1	0.1	0	0.2	0	0	0	0.1	0	0	0.2	0
	Data security	0.1	0.1	0	0.3	0	0	0.1	0.1	0	0	0.2	0.1
	Organization of global network servers	0	0.1	0	0	0	0.1	0.1	0.1	0.1	0.1	0	0
	Total	1	1	1	1	1	1	1	1	1	1	1	1

Figure 4: Coefficients of dependence of disciplines in the third year

5. Results & Discussion

To present the results of the system, a conditional group of five students and their simulated academic performance was created. The following figures will demonstrate the dependence of one student's success on a professional course to form a set of elective subjects for subsequent courses.

Figure 5 shows the performance of conditional student Avramenko O. in the first year, and Figure 6 shows Dyriv H.

			Elective disciplines							
№	Coefficient (percentage of success)	Mark	DC	WP	BST	NM	CL	BID	EG	EFSD
Normative discipline	Fundamentals of programming	95	0	38	9.5	0	0	0	0	0
	Object-oriented programming	96	0	48	38.4	0	0	19.2	0	0
	Fundamentals of software engineering	92	0	9.2	46	18.4	0	46	82.8	27.6
	Computer architecture	90	27	0	0	0	72	18	0	0
	Discrete Math	85	17	0	0	68	17	0	8.5	59.5
	Physics	85	42.5	0	0	0	0	8.5	0	0
	Total		86.5	95.2	93.9	86.4	89	91.7	91.3	87.1

Figure 5: An example of the formation of optional subjects for the second year for the student Avramenko

			Elective disciplines							
№	Coefficient (percentage of success)	Mark	DC	WP	BST	NM	CL	BID	EG	EFSD
Normative discipline	Fundamentals of programming	75	0	30	7.5	0	0	0	0	0
	Object-jriented programming	65	0	32.5	26	0	0	13	0	0
	Fundamentals of software engineering	92	0	9.2	46	18	0	46	82.8	27.6
	Computer architecture	85	25.5	0	0	0	68	17	0	0
	Discrete Math	75	15	0	0	60	15	0	7.5	52.5
	Physics	78	39	0	0	0	0	7.8	0	0
	Total		79.5	71.7	79.5	78	83	83.8	90.3	80.1

Figure 6: An example of the formation of optional disciplines for the second year for the student Dyriv

Therefore, two optional disciplines from the first year, namely "Web programming" and "Basis of smart technologies" (Avramenko), "Basis of interaction design" and "Engineering graphics" (Dyriv) are included in the student's curriculum for the next year and, accordingly , according to the results of the

assessment and examination session, will be evaluated for a certain point. All other optional disciplines from the first year are "zeroed". From here, based on the performance evaluations of a conditional student in the second year, we will receive two elective subjects for the third year: "Modern software development platforms" and "Basis of cloud technologies" (Avramenko) and "Basis of cloud technologies" and "Data security" (Dyriv) (see Fig. 7-8).

			Elective disciplines											
№	Coefficient (percentage of success)	Mark	MSDP	PMP	SAI	ML	CSAI	ES	DMSN	WCS	BCT	IS	DS	OGNS
Normative discipline	System analysis	80	0	0	0	0	8	24	0	8	8	0	0	8
	Requirements analysis	88	0	0	0	0	0	26.4	0	8.8	8.8	8.8	8.8	0
	Database design	90	9	9	0	0	0	0	0	0	9	9	27	9
	Object-oriented programming	95	9.5	9.5	0	9.5	0	0	0	0	19	19	0	0
	Algorithms and data structures	85	25.5	34	8.5	8.5	8.5	0	17	17	17	17	25.5	17
	Operating Systems	81	16.2	8.1	16.2	8.1	8.1	0	16.2	8.1	0	0	0	16.2
	Higher mathematics	62	0	0	6.2	6.2	6.2	6.2	0	0	0	6.2	0	0
Selective from the 1st year	Digital circuitry	0	0	0	0	0	0	0	0	0	0	0	0	0
	Web programming	92	18.4	0	0	0	0	0	0	0	9.2	0	0	9.2
	Basics of Smart technologies	82	8.2	8.2	0	8.2	0	0	0	0	8.2	8.2	0	0
	Numerical Methods	0	0	0	0	0	0	0	0	0	0	0	0	0
	Computer logic	0	0	0	0	0	0	0	0	0	0	0	0	0
	Basics of interaction design	0	0	0	0	0	0	0	0	0	0	0	0	0
	Engineering graphics	0	0	0	0	0	0	0	0	0	0	0	0	0
	Economic foundations of software development	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total		86.8	68.8	30.9	41	30.8	56.6	33.2	41.9	79.2	68.2	61.3	59.4

Figure 7: An example of the formation of optional subjects for the third year for the student Avramenko

			Elective disciplines											
№	Coefficient (percentage of success)	Mark	MSDP	PMP	SAI	ML	CSAI	ES	DMSN	WCS	BCT	IS	DS	OGNS
Normative discipline	System analysis	80	0	0	0	0	8	24	0	8	8	0	0	8
	Requirements analysis	92	0	0	0	0	0	27.6	0	9.2	9.2	9.2	9.2	0
	Database design	72	7.2	7.2	0	0	0	0	0	0	7.2	7.2	21.6	7.2
	Object-oriented programming	70	7	7	0	7	0	0	0	0	14	14	0	0
	Algorithms and data structures	88	26.4	35.2	8.8	8.8	8.8	0	17.6	17.6	17.6	17.6	26.4	17.6
	Operating Systems	61	12.2	6.1	12.2	6.1	6.1	0	12.2	6.1	0	0	0	12.2
	Higher mathematics	75	0	0	7.5	7.5	7.5	7.5	0	0	0	7.5	0	0
Selective from the 1st year	Digital circuitry	0	0	0	0	0	0	0	0	0	0	0	0	0
	Web programming	0	0	0	0	0	0	0	0	0	0	0	0	0
	Basics of Smart technologies	0	0	0	0	0	0	0	0	0	0	0	0	0
	Numerical Methods	0	0	0	0	0	0	0	0	0	0	0	0	0
	Computer logic	0	0	0	0	0	0	0	0	0	0	0	0	0
	Basics of interaction design	82	0	8.2	8.2	0	8.2	0	16.4	8.2	8.2	0	8.2	8.2
	Engineering graphics	90	0	0	0	0	0	0	9	9	0	0	0	0
	Economic foundations of software development	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total		52.8	63.7	36.7	29	38.6	59.1	55.2	58.1	64.2	55.5	65.4	53.2

Figure 8: An example of the formation of optional disciplines for the third year for a student of Dyriv

By analogy with the formation of elective disciplines for the third year, we are forming elective disciplines for students for the fourth year of study. From here, based on the performance evaluations of a conditional student in the third year, we will receive two optional subjects for the fourth year: "Computer graphics" and "Basis of cloud technologies" (Avramenko) and "Data compression methods" and "Data transmission systems" (Dyriv) (see Fig. 9-10).

			Elective disciplines											
№	Coefficient (percentage of success)	Mark	IT	GT	ESM	DCM	CG	BST	DPES	CC	HMI	CIS	DTS	DSFPGA
Normative discipline	Database programming tools	93	9.3	9.3	0	18.6	0	9.3	9.3	0	0	0	27.9	0
	Organization of computer networks	80	8	8	0	0	0	8	16	8	8	8	8	0
	Professional practice	70	7	0	21	0	7	0	0	0	7	0	0	0
	Software testing quality	88	8.8	0	8.8	17.6	26.4	8.8	0	8.8	0	0	8.8	0
	Software modeling and analysis	91	0	0	0	0	18.2	0	0	0	0	0	0	0
	Programming of cyber-physical systems	85	8.5	0	8.5	8.5	0	8.5	8.5	8.5	8.5	17	8.5	8.5
	Software design	92	0	0	0	0	9.2	9.2	0	0	0	9.2	0	18.4
Selective from the 2nd year	Modern software development platforms	96	9.6	9.6	0	0	9.6	9.6	9.6	0	0	19.2	0	19.2
	Programming of mobile platforms	0	0	0	0	0	0	0	0	0	0	0	0	0
	The structure of artificial intelligence	0	0	0	0	0	0	0	0	0	0	0	0	0
	Machine learning	0	0	0	0	0	0	0	0	0	0	0	0	0
	Computer systems of artificial intelligence	0	0	0	0	0	0	0	0	0	0	0	0	0
	Economics of software	0	0	0	0	0	0	0	0	0	0	0	0	0
	Design of multi-service networks	0	0	0	0	0	0	0	0	0	0	0	0	0
	Wireless communication systems	0	0	0	0	0	0	0	0	0	0	0	0	0
	Basics of cloud technologies	88	8.8	0	0	0	0	17.6	0	0	8.8	0	0	0
	Informational security	0	0	0	0	0	0	0	0	0	0	0	0	0
	Data security	0	0	0	0	0	0	0	0	0	0	0	0	0
	Organization of global network servers	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total		60	26.9	38.3	44.7	70.4	71	43.4	25.3	32.3	53.4	53.2	46.1

Figure 9: An example of the formation of optional subjects for the fourth year for the student Avramenko

			Elective disciplines											
№	Coefficient (percentage of success)	Mark	IT	GT	ESM	DCM	CG	BST	DPES	CC	HMI	CIS	DTS	DSFPGA
Normative discipline	Database programming tools	85	8.5	8.5	0	17	0	8.5	8.5	0	0	0	25.5	0
	Organization of computer networks	77	7.7	7.7	0	0	0	7.7	15.4	7.7	7.7	7.7	7.7	0
	Professional practice	65	6.5	0	19.5	0	6.5	0	0	0	6.5	0	0	0
	Software testing quality	93	9.3	0	9.3	18.6	27.9	9.3	0	9.3	0	0	9.3	0
	Software modeling and analysis	88	0	0	0	0	17.6	0	0	0	0	0	0	0
	Programming of cyber-physical systems	60	6	0	6	6	0	6	6	6	6	12	6	6
	Software design	81	0	0	0	0	8.1	8.1	0	0	0	8.1	0	16.2
Selective from the 2nd year	Modern software development platforms	0	0	0	0	0	0	0	0	0	0	0	0	0
	Programming of mobile platforms	0	0	0	0	0	0	0	0	0	0	0	0	0
	The structure of artificial intelligence	0	0	0	0	0	0	0	0	0	0	0	0	0
	Machine learning	0	0	0	0	0	0	0	0	0	0	0	0	0
	Computer systems of artificial intelligence	0	0	0	0	0	0	0	0	0	0	0	0	0
	Economics of software	0	0	0	0	0	0	0	0	0	0	0	0	0
	Design of multi-service networks	0	0	0	0	0	0	0	0	0	0	0	0	0
	Wireless communication systems	0	0	0	0	0	0	0	0	0	0	0	0	0
	Basics of cloud technologies	92	9.2	0	0	0	0	18.4	0	0	9.2	0	0	0
	Informational security	0	0	0	0	0	0	0	0	0	0	0	0	0
	Data security	84	8.4	8.4	0	25.2	0	0	8.4	8.4	0	0	16.8	8.4
	Organization of global network servers	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total		55.6	24.6	34.8	66.8	60.1	58	38.3	31.4	29.4	27.8	65.3	30.6

Figure 10: An example of the formation of optional disciplines for the fourth year for a student of Dyriv

The software implementation of the method is given below [13, 14]. Figures 11 and 12 show the progress tables of first-year and third-year students, respectively.

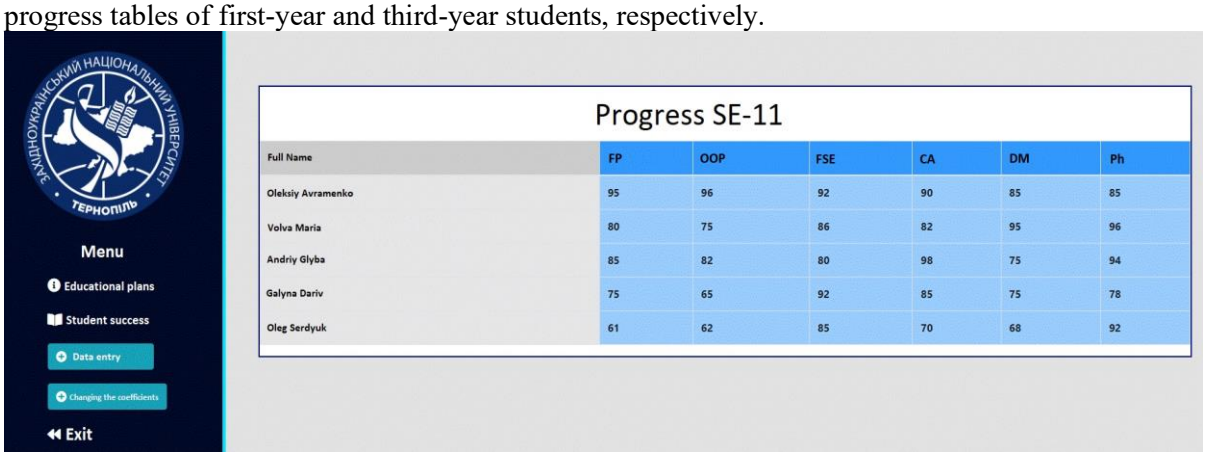
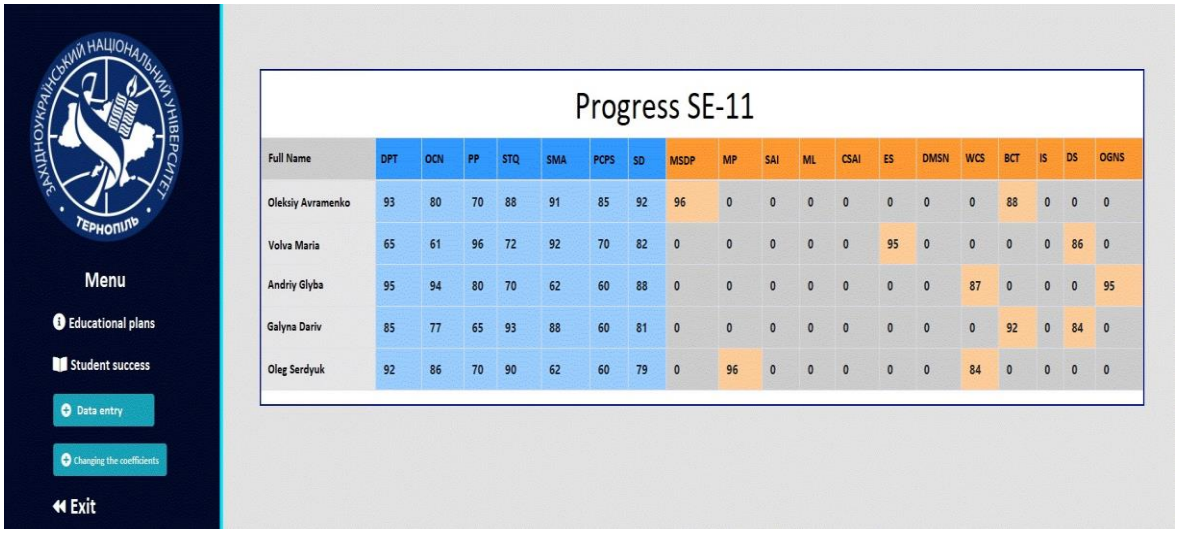


Figure 11: Progress page of the first year group

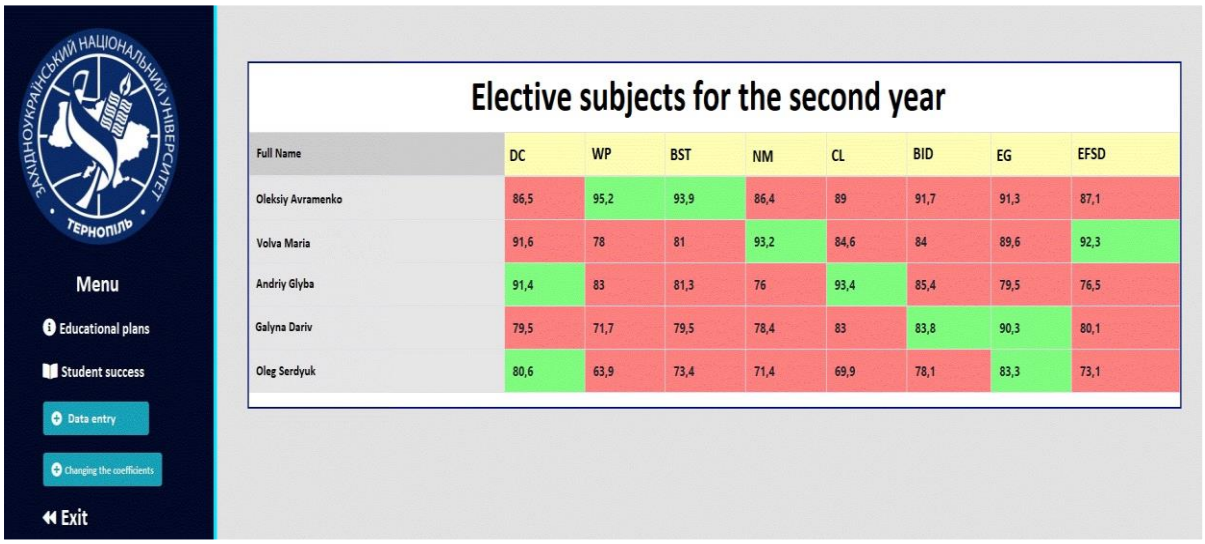


Full Name	DPT	OCN	PP	STQ	SMA	PCPS	SD	MSDP	MP	SAI	ML	CSAI	ES	DMSN	WCS	BCT	IS	DS	OGNS
Oleksiy Avramenko	93	80	70	88	91	85	92	96	0	0	0	0	0	0	0	88	0	0	0
Volva Maria	65	61	96	72	92	70	82	0	0	0	0	0	95	0	0	0	0	86	0
Andriy Glyba	95	94	80	70	62	60	88	0	0	0	0	0	0	0	87	0	0	0	95
Galyna Dariv	85	77	65	93	88	60	81	0	0	0	0	0	0	0	0	92	0	84	0
Oleg Serdyuk	92	86	70	90	62	60	79	0	96	0	0	0	0	0	84	0	0	0	0

Figure 12: Progress page of the third year group

After the grades for all subjects have been posted, the page for viewing the student's calculated individual plan for the next year will be available.

Figure 13 shows the page of elective subjects assigned to the respective students, which will be added to the normative ones in the students' curriculum for the second year.



Full Name	DC	WP	BST	NM	CL	BID	EG	EFSD
Oleksiy Avramenko	86,5	95,2	93,9	86,4	89	91,7	91,3	87,1
Volva Maria	91,6	78	81	93,2	84,6	84	89,6	92,3
Andriy Glyba	91,4	83	81,3	76	93,4	85,4	79,5	76,5
Galyna Dariv	79,5	71,7	79,5	78,4	83	83,8	90,3	80,1
Oleg Serdyuk	80,6	63,9	73,4	71,4	69,9	78,1	83,3	73,1

Figure 13: Page of the calculated curriculum for the next year

6. Conclusions

The article considers the problem of forming a student's individual study plan, in particular, on the basis of the elective subjects chosen by the student. It is noted that currently students choose elective subjects arbitrarily, based on the principle of mass or certain "interest". Quite often, as a result, the student simply does not like the discipline he has chosen. The authors proposed to make the method to the selection of elective subjects automated, namely by developing a method of forming an individual study plan for each individual student, taking as a basis success indicators from previously studied subjects. From here, the normative part of the subjects will build the basis of the specialist as such, and a number of elective disciplines formed on the basis of the student's performance indicators will only improve and increase knowledge in those areas where the student is the best. Thus, using the specified method of forming a student's individual educational plan, a higher educational institution will be able to form highly qualified specialists, relying on their personal abilities and educational achievements.

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