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FUZZY FORMALIZATION AND AUTOMATION OF THE PROCESS OF SPECIAL ACADEMIC SCHOLARSHIP DISTRIBUTION IN HIGHER EDUCATIONAL INSTITUTIONS

Abstract. The article deals with the vital task of efficient distribution of the scholarship fund during the formation of the budgetary policy at higher educational institutions of Ukraine. The practice of distribution of the scholarship fund of higher educational institutions is analyzed, the existing forms of awarding scholarships to Ukraine's university students are described. The necessity of taking into account students' educational and extracurricular achievements, as well as motivational educational factors, during assignment of scholarships was determined, while providing desubjectization of the process of awarding scholarships itself. An idea of the peculiarities of the scholarship fund distribution is represented on the example of the Donbass State Engineering Academy (DSEA). The process of making decisions on the appointment of special scholarships under the conditions of ambiguity of qualitative and quantitative evaluation criteria is considered. The formalization of the distribution process of academic scholarships using the fuzzy sets theory is given. Scholarships are presented in the form of alternative situations, each of which has its own rating value of a potential candidate for a scholarship. The factors influencing the choice of the candidate include academic progress, results of public and scientific activities. The linguistic variables defined on the five-level term-set are determined for each given factor. Trapezoidal membership functions are used for describing the linguistic variables. The results of approbation of the proposed methodology are represented on the example of Intelligent decision support systems department of the DSEA. The fuzzy classification of factors and the folding of the classification levels obtained into the general rating assessment of the candidates as an average weighted for all the indicators involved in the assessment and for all qualitative levels of these indicators were made. The list of candidates for receiving of scholarships according to the procedure proposed by the authors was formed as an example for the Intelligent decision support systems department of the DSEA. The machine-assisted realization of the methodology of special academic scholarships distribution was carried out in the form of a software modulus of the department web-system.

Keywords: scholarship fund; evaluation of student`s academic and non-academic achievements; fuzzy formalization problem; assignment of scholarships; fuzzy sets; web-application.

1. INTRODUCTION

Problem statement. One of the important aspects of the budgetary policy formation of the higher educational institution today is the effective allocation of the scholarship fund, which should be based on an objective and comprehensive assessment of students' achievements. An important condition for the solution of this problem is the selection for assessment of the indicators of student learning activity, where the modular-ranking system makes a mandatory requirement - they must have a quantitative interpretation (ranking grades) [1]. However, it is also obvious that it is necessary to take into account not only

students' educational but also extracurricular achievements, as well as motivational educational factors [2], which adapt to new conditions and acquire new features [3].

Scholarships for the students' achievement (academic, special, personal scholarships, etc.), as well as their fair distribution, are key factors in the students' interest in the educational process. This, in turn, requires desubjectivization of the management process of the scholarship fund available at the higher educational institution by introducing modern information technologies.

Analysis of the last researches and publications. According to the studies [5], the distribution of the scholarship fund in different countries can be considered as the financing of the state social project on work with youth. So, in the USA scholarships are part of the grant policy of individual states. In Finland, [6] a special agency has been set up, which is the center of international mobility, manages scholarship programs and exchange projects.

Students of Ukrainian universities can also apply for scholarships in various European educational programs [7]. For example, in the framework of mutual cooperation in 2000, an international ASEM-DUO program was implemented between the countries of Europe and Asia, where students from different countries were trained in partner countries, and can receive financial scholarship support.

In Ukraine, the scholarship policy is regulated by the state, and the Cabinet of Ministers of Ukraine with the participation of the Ministry of Education and Science of Ukraine approves the list of special scholarships. For the current year, the Cabinet of Ministers of Ukraine approved a list of special scholarships for students of higher educational institutions. Among them: the academic scholarship named after Taras Bilchuk [8], the academic scholarship of Heroes of Heaven Hundreds [9], academic scholarships of statesmen of the first Ukrainian government [10], academic grants of the President of Ukraine [11], academic grants of the Cabinet of Ministers of Ukraine [12], academic scholarships of the councils of universities, as well as special university scholarships named after outstanding scientific figures. Besides the listed types of scholarships, additional payments to students are provided as supplementary, for talented youth at the expense of charitable foundations operating in Ukraine and at the expense of key regional employers.

In the modern conditions, it is very important that the scholarship policy of the educational institution should not be limited by the state budget funds, but be aimed at intensifying investment flows from other subjects, in particular, from business and social partners [13], which will positively affect the employment of future graduates.

Modern science considers the problem of material incentives for students from different perspectives. In particular, studies have been conducted to assess the impact of scholarships on student progress, as well as on their further personal growth [14]. University scholarships significantly affect student success that can be measured by a number of factors. In fact, the impact of university scholarships is stronger than all other variables included in all mathematical models, though other awards for need-based aid and estimated family contribution are also important.

In [15] advanced the hypothesis of the dependence of the "effectiveness" of material incentives for students on the essential characteristics of the scholarship recipient, that is, on the students' race, gender, as well as on their income level. Author's results show that universal scholarships can reach many students and have a high rate of return.

It should also be noted that when conducting research in the field of decision-making on the distribution of the scholarship fund, various mathematical methods, statistical analysis methods, and modeling are used. For example, in the study [16], the authors proposed the scholarship assignment algorithms based on the dynamic programming method, which ensure the objectivity of decision making by the university administration.

In [17], the features of the application of Bayesian estimates for the selection of the optimal applicant for a scholarship have been considered. This study presents scholarship assessment mathematical model that can provide recommendation by considering the aspects of the student's academic term, GPa, economic ability, and organizational involvement, with a high degree of accuracy.

In the classical version, the decision-making process for appointing special scholarships goes through several iterations: from consideration of applicants for special scholarships by their departments to the approval of these applicants by the academic councils of faculties and universities. The process of special scholarship appointing at the state level is not regulated and is completely controlled by local normative acts of higher educational institutions. Therefore, it is important to minimize the risk of non-objective appointment of special scholarships and develop a procedure for impersonal appointment of scholarships based on the criteria for assessing the academic and extracurricular achievements of students.

During developing such a procedure, there is a risk of failure to clearly formalize the rules for awarding scholarships, due to the availability of both quantitative and qualitative results of students' learning and extracurricular activities. The potential risk can be eliminated through the fuzzy formalization of the task of distributing special scholarships. The use of fuzzy descriptions will allow, on the one hand, carrying out qualitative and quantitative multi-criteria analysis of applicants, and on the other hand, to reduce the level of subjectivity of the decision to allocate the scholarship fund.

The aim of the article is to investigate the applicability of fuzzy logic methods in the distribution of special academic scholarships in a higher educational institution.

2. BACKGROUND OF THE STUDY

Let us consider the distribution of the scholarship fund by the example of Donbas State Engineering Academy (Donetsk region, Ukraine, for short – DSEA).

The following types of academic scholarships are granted in DSEA [18]:

1) scholarships founded by the President of Ukraine, the Verkhovna Rada of Ukraine, the Cabinet of Ministers of Ukraine (including personal ones), which are assigned to students and graduate students on the basis of learning outcomes for certain educational (educational and qualification) levels

2) ordinary (regular) academic scholarships;

3) Scholarships in an increased amount:

– for students, who have achieved special academic success;

– for students studying in specialties (specializations), for which an increased amount of the academic scholarship has been officially established and approved.

If the scholarship holder has the right to several academic scholarships, one scholarship of the largest size is paid unless otherwise provided by law.

Within the funds provided for the payment of scholarships, students are awarded academic scholarships according to the academic ranking. Academic rankings are formed by the Scholarship commissions of the faculties based on the results of the final semester control of the previous academic semester for each faculty, academic year, and for each specialty (direction of training) based on academic progress in each subject (academic discipline), defence of course projects (papers) and reports on practice taking into account participation in R&D, public life and sports activities. At the same time, the component of the progress (defined in grades, based on the 100-grade system of knowledge assessment) is at least 90 percent of the ranking grade.

The average quality grade of the student is calculated by the formula [19]:

$$R = K_{ap} \cdot \frac{K_1 \cdot R_1 + K_2 \cdot R_2 + ... + K_n \cdot R_n}{\sum K_i} + K_{pa} \cdot R_{ad}, \quad (1)$$

where K_{ap} – weight assignment of evaluation for academic progress, K_{ap} = 0,90;

K_i – the number of credits for the relevant discipline, course work (project), practice;

R_i – the final ranking score of the student on a 100-grade scale for the corresponding (i-th) academic discipline (an academic subject), course work (project), and practice;

$\sum K_i$ – the amount of credits for disciplines, course work (projects), practical trainings for the relevant period;

K_{pa} – weight assignment of evaluation for participation in R&D, public life, creative and sports activities, $K_{\partial\partial}$ = 0,1.

R_{ad} – an additional quality grade for participation in R&D, public life, creative and sports activities ($0 \le R_\partial \le 100$):

$$R_{ad} = \sum R^i{}_{ad} = R^1{}_{ad} + R^2{}_{ad} + ... + R^i{}_{ad}, \quad (2)$$

where $R^1{}_{ad} + R^2{}_{ad} + ... + R^i{}_{ad}$ – additional quality grades for each type of work (educational, scientific and social activities).

Students with the highest academic ranking are awarded the total payment amount within the funds provided for this purpose.

As for special academic scholarships, the DSEA has the following types:

- academic scholarship of the President of Ukraine;
- academic scholarship of the Verkhovna Rada of Ukraine;
- academic scholarship of the Cabinet of Ministers of Ukraine;
- academic scholarship of the Regional Council of People`s Deputies;
- academic scholarship of PJSC «Novokramatorsky mashinostroitelny zavod»;
- academic scholarship of the Academic Council of the DSEA.

Only a student who has the right to receive an academic scholarship can apply for a special scholarship.

The university department responsible for the student's training program forms the list of applicants for special scholarships; it is submitted for approval to the academic council of the faculty and further to the Scientific Council of the DSEA.

3. METHODOLOGY OF THE STUDY

During the process of selecting applicants for a certain type of special academic scholarship, we will use a set of quantitative and qualitative factors. In this case, all factors are measurable, i.e. have a carrier with its domain of definition on the real axis.

Scholarships are presented in the form of alternative situations:

S_1 – academic scholarship of the President of Ukraine;

S_2 – academic scholarship of the Verkhovna Rada of Ukraine;

S_3 – academic scholarship of the Cabinet of Ministers of Ukraine;

S_4 – academic scholarship of the regional Council of the People`s Deputies;

S_5 – academic scholarship of PJSC «Novokramatorsky mashinostroitelny zavod»;

S_6 – academic scholarship of the Academic Council of DSEA.

Each situation has its own ranking; its fuzzy description of the factors affecting it.

The factors influencing the choice of the applicant include the student's academic performance, the results of the public and scientific activity. We define the linguistic variable *E* "Applicant academic ranking", on the basis of which a decision will be made about the appointment of a scholarship.

Variable *E* can take one of five values:

E_1 – fuzzy subsets of «extremely inadequate»;

E_2 – fuzzy subsets of «insufficient»;

E_3 – fuzzy subsets of «average»;

E_4 – fuzzy subsets of «relatively sufficient»;

E_5 – fuzzy subsets of «sufficient».

The carrier of the set *E* can take values from zero to one (in the normalized form).

Next, we introduce a set of individual factors $X = \{ X_i \}$ that, on the one hand, affect the magnitude of the ranking, and, on the other hand, evaluate the different aspects of the student's activities in nature (to avoid duplication of indicators in terms of their significance for analysis).

The system of factors will have the following form:

X_1 – performance level;

X_2 – social activity;

X_3 – scientific activity.

For each given factor X_i, that affects the value of the ranking, we set the linguistic variable B_i «Factor value X_i» on the following term set of values:

B_{i1} – subset «low factor value X_i»;

B_{i2} – subset «value factor X_i below the average»;

B_{i3} – subset «average value of factor X_i»;

B_{i4} – subset «value of factor X_i above average»;

B_{i5} – subset «high factor X_i value ».

For a fuzzy description of the factors, as well as the linguistic variable *E*, we use the trapezoidal membership functions, which are represented by trapezoidal numbers of the form:

$$\mu(x)=\begin{cases}1-\dfrac{x-a}{b-a}, & a\le x\le b\\ 1, & b\le x\le c\\ 1-\dfrac{x-c}{d-c}, & c\le x\le d\\ 0, & othercases\end{cases}, \quad (3)$$

where a and d – abscissae of the lower base; b and c – abscissae of the upper base of the trapezium, setting $\mu(x)$ in a domain with a nonzero membership of the carrier to the corresponding fuzzy subset.

The abscissae of the lower and upper bases of the trapezium are established expertly based on the values of the carrier represented in the normalized form on the interval [0; 1].

The classifier of students' ranking developed using scientific results obtained in [20] is presented in Table 1.

Table 1

Ranking classification

Interval of ranking range (R)	Classification of the parameter level	The degree of estimated confidence (membership function)
0≤ R ≤0.15	E_5	1
0.15< R <0.25	E_5	$\mu_5=10\cdot(0.25-R)$
	E_4	$1-\mu_{5=}\mu_4$
0.25≤ R ≤0.35	E_4	1
0.35< R <0.45	E_4	$\mu_4=10\cdot(0.45-R)$
	E_3	$1-\mu_4=\mu_3$
0.45≤ R≤0.55	E_3	1
0.55< R <0.65	E_3	$\mu_3=10\cdot(0.65-R)$
	E_2	$1-\mu_3=\mu_2$
0.65≤ R ≤0.75	E_2	1
0.75< R <0.85	E_2	$\mu_2=10\cdot(0.85-R)$
	E_1	$1-\mu_2=\mu_1$
0.85≤ R ≤1.0	E_1	1

During the determination of the fuzzy value of the ranking, it is necessary to take into account the significance of the factors. Let us compare each factor X_i to the level of its significance for analysis r_i. To assess this level, you need to arrange all the indicators in order of decreasing significance so that the rule [20] is fulfilled:

$$r_i \ge r_2 \ge \ldots r_N . \quad (4)$$

We can determine the significance of i-st factor r_i according to the Fishburn`s rule [20]:

$$r_i = \frac{2(N \quad i+1)}{(N+1)N} . \tag{5}$$

At the next stage, we will form a set of classifiers of the current values of factors *X* as a criterion for splitting the complete set of their values into fuzzy subsets of the form *B* (table 2). In this case, the cells of the table are trapezoidal numbers that characterize the corresponding membership functions. It must be noted that the classification would differ for each individual situation (a separate type of scholarship).

Table 2

Factors classification

Factor	**Terms of values of the linguistic variable "Factor value".**				
	«low»	**«below the average»**	**«average»**	**«above average»**	**«high»**
Situation 1 (S_1)					
X_1	(0; 0; 0,3; 0,4)	(0,3; 0,4; 0,45; 0,55)	(0,45; 0,55; 0,6; 0,65)	(0,6; 0,65; 0,8; 0,9)	(0,8; 0,9; 1;1)
X_2	(0; 0; 0,3; 0,35)	(0,3; 0,35; 0,4; 0,5)	(0,4; 0,5; 0,55; 0,6)	(0,55; 0,6; 0,7; 0,8)	(0,7; 0,8; 1;1)
X_3	(0; 0; 0,4; 0,45)	(0,4; 0,45; 0,5; 0,55)	(0,5; 0,55; 0,6; 0,65)	(0,65; 0,7; 0,9; 0,95)	(0,9; 0,95; 1;1)
Situation 2 (S_2)					
X_1	(0; 0; 0,3; 0,35)	(0,3; 0,35; 0,4; 0,5)	(0,4; 0,5; 0,75; 0,85)	(0,55; 0,6; 0,75; 0,85)	(0,75; 0,85; 1;1)
X_2	(0; 0; 0,3; 0,35)	(0,3; 0,35; 0,4; 0,45)	(0,4; 0,45; 0,65; 0,75)	(0,5; 0,55; 0,65; 0,75)	(0,65; 0,75; 1;1)
X_3	(0; 0; 0,4; 0,45)	(0,4; 0,45; 0,5; 0,55)	(0,5; 0,55; 0,6; 0,65)	(0,65; 0,7; 0,9; 0,95)	(0,9; 0,95; 1;1)
Situation 3 (S_3)					
X_1	(0; 0; 0,3; 0,35)	(0,3; 0,35; 0,4; 0,5)	(0,4; 0,5; 0,75; 0,85)	(0,55; 0,6; 0,75; 0,85)	(0,75; 0,85; 1;1)
X_2	(0; 0; 0,3; 0,35)	(0,3; 0,35; 0,4; 0,45)	(0,4; 0,45; 0,65; 0,75)	(0,5; 0,55; 0,65; 0,75)	(0,65; 0,75; 1;1)
X_3	(0; 0; 0,35; 0,4)	(0,35; 0,4; 0,45; 0,5)	(0,45; 0,5; 0,85; 0,9)	(0,6; 0,65; 0,85; 0,9)	(0,85; 0,9; 1;1)
Situation 4 (S_4)					
X_1	(0; 0; 0,3; 0,35)	(0,3; 0,35; 0,4; 0,5)	(0,4; 0,5; 0,75; 0,85)	(0,55; 0,6; 0,75; 0,85)	(0,75; 0,85; 1;1)
X_2	(0; 0; 0,35; 0,4)	(0,35; 0,4; 0,45; 0,5)	(0,45; 0,5; 0,85; 0,9)	(0,6; 0,65; 0,85; 0,9)	(0,85; 0,9; 1;1)
X_3	(0; 0; 0,3; 0,35)	(0,3; 0,35; 0,4; 0,45)	(0,4; 0,45; 0,65; 0,75)	(0,5; 0,55; 0,65; 0,75)	(0,65; 0,75; 1;1)
Situation 5 (S_5)					
X_1	(0; 0; 0,4; 0,45)	(0,4; 0,45; 0,5; 0,55)	(0,5; 0,55; 0,6; 0,65)	(0,65; 0,7; 0,9; 0,95)	(0,9; 0,95; 1;1)
X_2	(0; 0; 0,3; 0,35)	(0,3; 0,35; 0,4; 0,45)	(0,4; 0,45; 0,65; 0,75)	(0,5; 0,55; 0,65; 0,75)	(0,65; 0,75; 1;1)
X_3	(0; 0; 0,3; 0,35)	(0,3; 0,35;	(0,4; 0,45;	(0,5; 0,55;	(0,65; 0,75; 1;1)

		0,4; 0,45)	0,65; 0,75)	0,65; 0,75)	
Situation 6 (S_6)					
X_1	(0; 0; 0,35; 0,4)	(0,35; 0,4; 0,45; 0,5)	(0,45; 0,5; 0,85; 0,9)	(0,6; 0,65; 0,85; 0,9)	(0,85; 0,9; 1;1)
X_2	(0; 0; 0,3; 0,35)	(0,3; 0,35; 0,4; 0,45)	(0,4; 0,45; 0,65; 0,75)	(0,5; 0,55; 0,65; 0,75)	(0,65; 0,75; 1;1)
X_3	(0; 0; 0,3; 0,35)	(0,3; 0,35; 0,4; 0,5)	(0,4; 0,5; 0,75; 0,85)	(0,55; 0,6; 0,75; 0,85)	(0,75; 0,85; 1;1)

To use Table 2, you need to go to the normalized values of the factors. Normalization can be performed by the method of relative normalization by comparison with the maximum value:

$$x_k / \max_k x_k, \tag{6}$$

where x_k – significance factor for *k-st* student.

Based on the above classifier (Table 2) and formula (3), the level of factors is recognized, i.e. we determine the level of ownership of the media x_i to the fuzzy subsets B_j (λ_{ij}) according to [20], Table 3.

Table 3

Levels of media accessories to fuzzy subsets

Factor	**The result of classification by fuzzy subsets**				
	B_{i1}	B_{i2}	B_{i3}	B_{i4}	B_{i5}
X_1	λ_{11}	λ_{12}	λ_{13}	λ_{14}	λ_{15}
X_1	λ_{21}	λ_{22}	λ_{23}	λ_{24}	λ_{25}
X_3	λ_{31}	λ_{32}	λ_{33}	λ_{34}	λ_{35}

Conversion of the obtained levels of classification of factors into the overall assessment of the ranking is carried out as a weight assignment for all participating in the assessment indicators on the one hand and for all qualitative levels of these indicators, on the other hand as follows [20]:

$$R = \sum_{j=1}^{5} K_j \sum_{i=1}^{N} r_i \lambda_{ij}, \tag{7}$$

where

$$K_j = 0.9 - 0.2 \cdot (j-1), \tag{8}$$

λ_{ij} is determined according to table 3, a r_i – by the formula (5).

According to the rating value, a list of candidates is formed to appoint each scholarship. For this set, applicants will be classified as "sufficient" and/or "relatively" ranked, but no more than 6 people (by the number of types of scholarships, provided that the department can only recommend one applicant for each type of scholarship).

4. RESULTS OF THE STUDY

Let us consider the practical implementation of the above method of distribution of special academic scholarships on the example of the Department of Intelligent Systems of Decision Making of the DSEA. For the control example, students of 2-4 years of study eligible for an academic scholarship were selected (Table 4).

Table 4

Applicants for special academic scholarships

Full name of the student	Group	Level of achievement, educational ranking (X_1)	Progress in scientific activity (X_2)	Progress in social activity (X_3)
Konovalenko D.A.	SA-16-1	99,50	0	25
Bagan S.V.	SM-15-1	98,11	50	15
Kadackij N.A.	SA-16-1	94,73	0	65
Tusheva A.A.	SM-15-1	93,67	20	0
Bulyga V.S.	SM-14-1	92,25	6	55
Sigida O.A.	SM-15-1	91,13	0	25

The results of factor normalization are shown in Table 5.

Table 5

Normalization of key factors of applicants for special academic scholarships

Full name of the student	X_1	X_2	X_3
Konovalenko D.A.	0,9950	0,00	0,25
Bagan S.V.	0,9811	0,50	0,15
Kadackij N.A.	0,9473	0,00	0,65
Tusheva A.A.	0,9367	0,20	0,00
Bulyga V.S.	0,9225	0,06	0,55
Sigida O.A.	0,9113	0,00	0,25

For each given factor X_i we set the linguistic variable B_i and E by the described above rules (table 1–2, formula (3)), thus forming a description of fuzzy situations (Table 6).

Table 6

Fuzzy description of factors

S	Full name of the student	Low $X_1/X_2/X_3$	Below the average $X_1/X_2/X_3$	Average $X_1/X_2/X_3$	Above average $X_1/X_2/X_3$	High $X_1/X_2/X_3$
S_1	Konovalenko D.A.	0/1/1	0/0/0	0/0/0	0/0/0	1/0/0
S_2		0/1/1	0/0/0	0/0/0	0/0/0	1/0/0
S_3		0/1/1	0/0/0	0/0/0	0/0/0	1/0/0
S_4		0/1/1	0/0/0	0/0/0	0/0/0	1/0/0

S_5		0/1/1	0/0/0	0/0/0	0/0/0	1/0/0
S_6		0/1/1	0/0/0	0/0/0	0/0/0	1/0/0
S_1	Bagan S.V.	0/0/1	0/0/0	0/1/0	0/1/0	1/0/0
S_2		0/0/1	0/0/0	0/1/0	0/1/0	1/0/0
S_3		0/0/1	0/0/0	0/1/0	0/0/0	1/0/0
S_4		0/0/1	0/0/0	0/1/0	0/1/0	1/0/0
S_5		0/0/1	0/0/0	0/1/0	0/1/0	1/0/0
S_6		0/0/1	0/0/0	0/1/0	0/0/0	1/0/0
S_1	Kadackij N.A.	0/1/0	0/0/0	0/0/1	0/0/1	1/0/0
S_2		0/1/0	0/0/0	0/0/1	0,054/0/1	0,054/0/1
S_3		0/1/0	0/0/0	0/0/1	0/0/1	1/0/1
S_4		0/1/0	0/0/0	0/0/1	0/0/1	1/0/0
S_5		0/1/0	0/0/0	0/0/0	0/0/1	1/0/0
S_6		0/1/0	0/0/0	0/0/0	0/0/1	1/0/0
S_1	Tusheva A.A.	0/1/1	0/0/0	0/0/0	0/0/0	1/0/0
S_2		0/1/1	0/0/0	0/0/0	0,266/0/0	0,266/0/0
S_3		0/1/1	0/0/0	0/0/0	0/0/0	1/0/0
S_4		0/1/1	0/0/0	0/0/0	0/0/0	1/0/0
S_5		0/1/1	0/0/0	0/0/0	0/0/0	1/0/0
S_6		0/1/1	0/0/0	0/0/0	0/0/0	1/0/0
S_1	Bulyga V.S.	0/1/0	0/0/0	0/0/1	0/0/1	1/0/0
S_2		0/1/0	0/0/0	0/0/1	0,55/0/1	0,55/0/0
S_3		0/1/0	0/0/0	0/0/1	0/0/1	1/0/0
S_4		0/1/0	0/0/0	0/0/1	0/0/0	1/0/0
S_5		0/1/0	0/0/0	0/0/1	0/0/0	1/0/0
S_6		0/1/0	0/0/0	0/0/1	0/0/0	1/0/0
S_1	Sigida O.A.	0/1/1	0/0/0	0/0/0	0/0/0	1/0/0
S_2		0/1/1	0/0/0	0/0/0	0,774/0/0	0,774/0/0
S_3		0/1/1	0/0/0	0/0/0	0/0/0	1/0/0
S_4		0/1/1	0/0/0	0/0/0	0/0/0	1/0/0
S_5		0/1/1	0/0/0	0/0/0	0/0/0	1/0/0
S_6		0/1/1	0/0/0	0/0/0	0/0/0	1/0/0

Conversion of the obtained levels of classification of factors into the overall assessment of the ranking was carried out as a weight average assignment for all participating in the evaluation indicators and for all qualitative levels of these indicators (Table 7). The following significance of factors is taken into account: r_1=0,6; r_2=0,7; r_3=0,8; k_1=0,9; k_2=0,7; k_3=0,5; k_4=0,3; k_5=0,1.

Table 7

Final fuzzy ranking of applicants

Full name of the student	S_1	S_2	S_3	S_4	S_5	S_6
Konovalenko D.A.	1,410	1,410	1,410	1,410	1,410	1,410
Bagan S.V.	1,340	1,340	1,130	1,340	1,340	1,130
Kadackij N.A.	1,330	1,363	1,410	1,330	0,930	0,930

Tusheva A.A.	1,410	1,414	1,410	1,410	1,410	1,410
Bulyga V.S.	1,330	1,402	1,330	1,090	1,090	1,090
Sigida O.A.	1,410	1,536	1,410	1,410	1,410	1,410

The result of the fuzzy distribution of scholarships is presented in Table 8.

Table 8

Final distribution of the scholarships

Full name of the student	Situation	Type of scholarship
Bagan S.V.	S_1	Scholarship of the President of Ukraine
Bulyga V.S.	S_2	Scholarship of the Verkhovna Rada of Ukraine
Kadackij N.A.	S_3	Scholarship of the Cabinet of Minister of Ukraine
Tusheva A.A.	S_4	Scholarship of the regional Council of the People`s Deputies
Sigida O.A.	S_5	ırship of PJSC « Novokramatorsky mashinostroitelny zavod»;
Konovalenko D.A.	S_6	Scholarship of the Academic Council of DSEA.

The formed list is the recommendation of the department for the appointment of special scholarships and is further submitted for consideration and approval to the members of the academic council of the faculty.

For the department of ISPR, the proposed methodology was implemented as a software module in the PHP language within the general web-system of the department (Fig. 1-3). This web-application has all interfaces in the Ukrainian language.

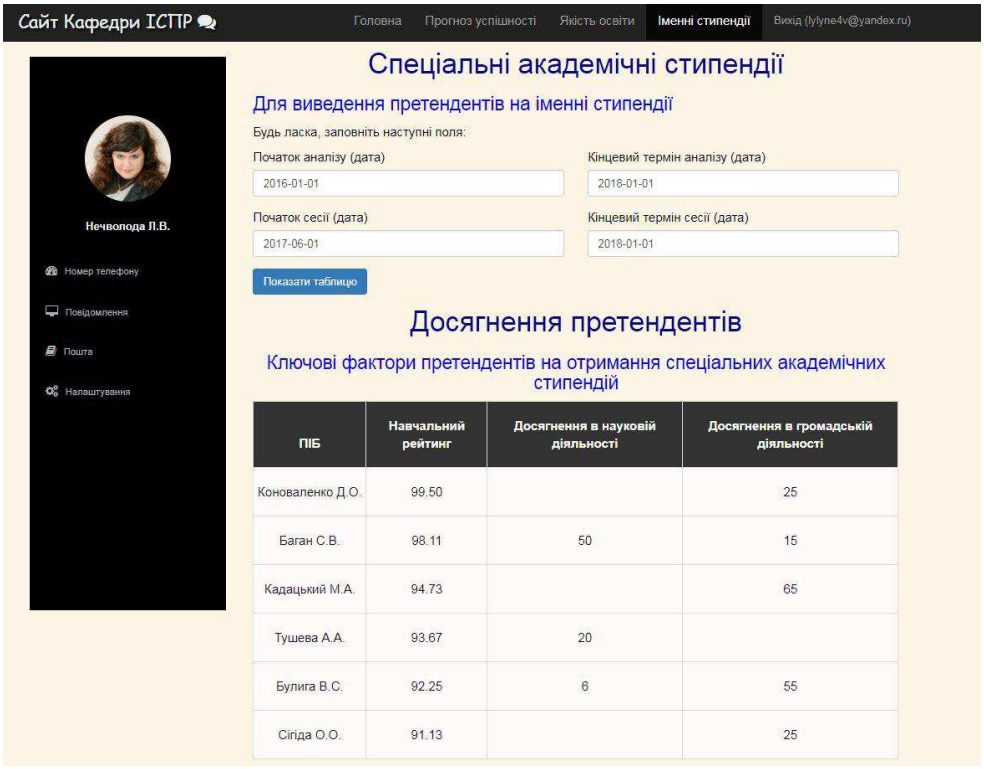

Fig.1. Automated selection of applicants for special academic scholarships

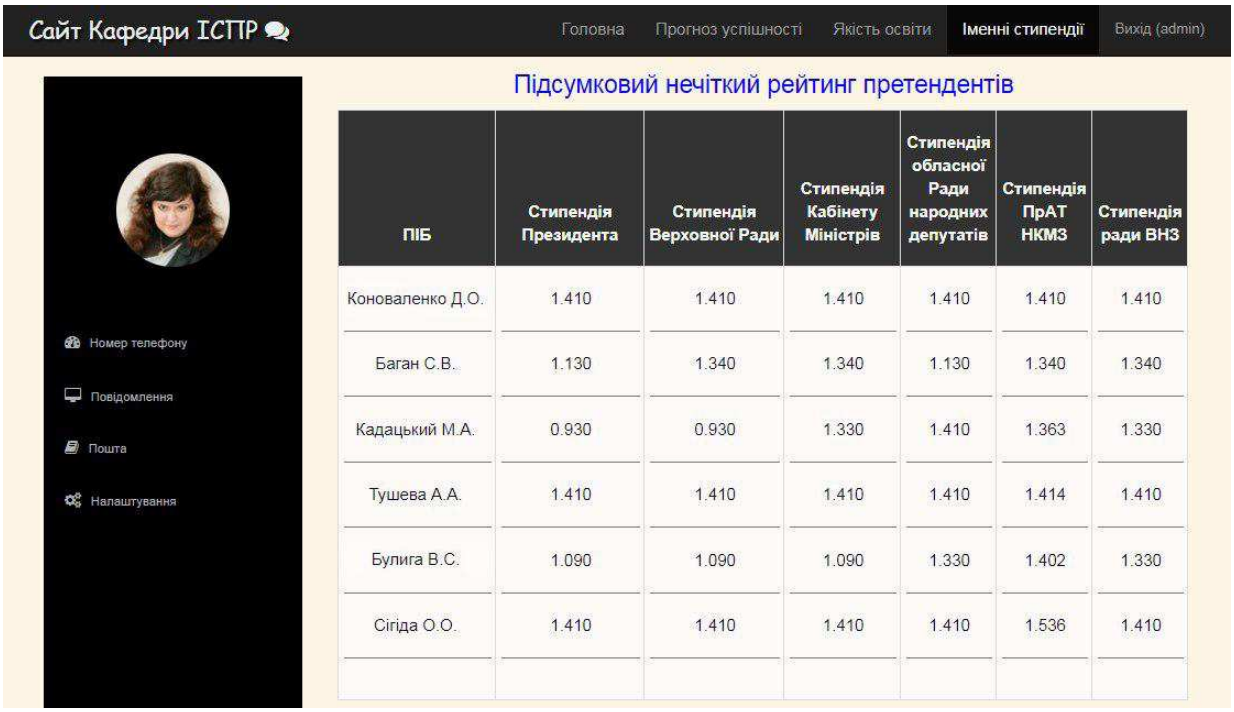

Fig. 2. Final fuzzy ranking of applicants

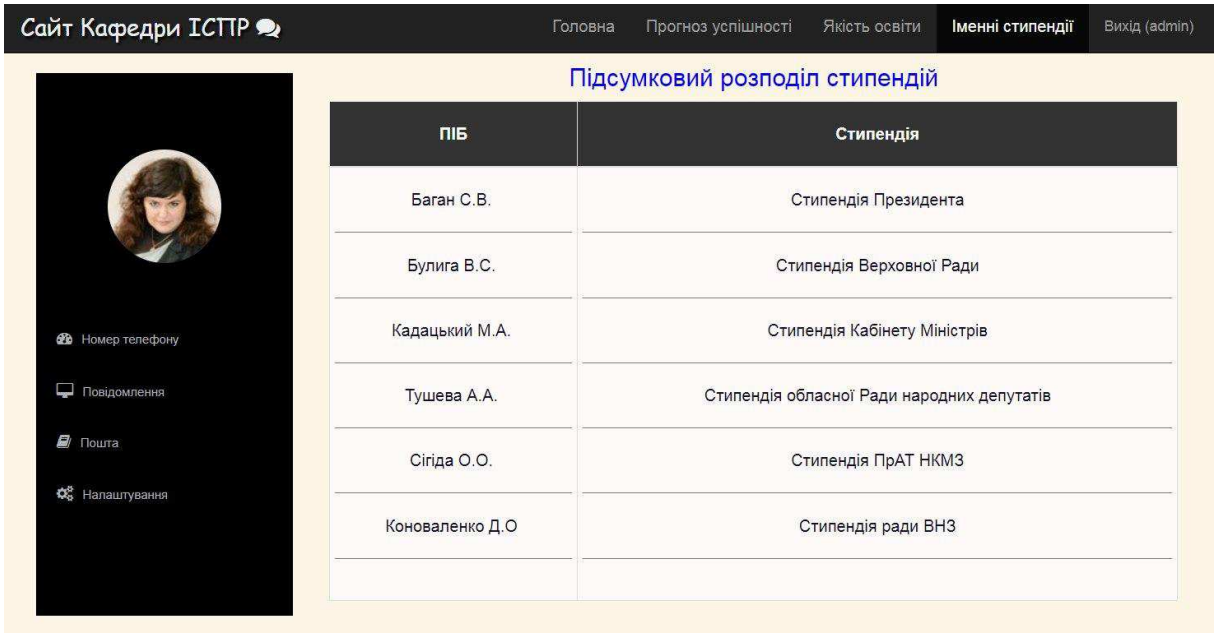

Fig. 3. Final distribution of the scholarships

5. CONCLUSIONS AND PROSPECTS FOR THE FURTHER STUDIES

The objective of the optimal and objective distribution of the scholarship fund is relevant for every higher educational institution in Ukraine. The image of the university, and, accordingly, its competitiveness largely depend on how scrupulously the administration of the university comes to grips with the problem, how reasonable are the criteria determining the appointment of scholarships.

Defining at the local level a list of criteria for awarding scholarships, one should follow several classical principles: substantive conformity, objectivity, transparency, ease of assessment, unambiguous interpretation. The criteria should take into account both academic progress and extracurricular activities, i.e. cover all areas of the student's performance, motivating them to develop a full-fledged socially oriented personality.

The use of fuzzy formalization of evaluating students' progress in appointing special scholarships makes it possible to resolve the problem of qualitative and quantitative assessment in controversial ambiguous conditions of the predominance of one type of achievement and eliminates the risk of subjective decision-making.

The proposed methodology can be adapted for each specific higher educational institution, and its software implementation will speed up the processing of a large array of information and ensure the objective allocation of special scholarships among the students.

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НЕЧІТКА ФОРМАЛІЗАЦІЯ І АВТОМАТИЗАЦІЯ ПРОЦЕСУ РОЗПОДІЛУ СПЕЦІАЛЬНИХ АКАДЕМІЧНИХ СТИПЕНДІЙ У ВИЩОМУ НАВЧАЛЬНОМУ ЗАКЛАДІ

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Анотація. У статті поставлене актуальне завдання ефективного розподілу стипендіального фонду при формуванні бюджетної політики вищого навчального закладу України. Проаналізована практика розподілу стипендіального фонду вишів, описані існуючі форми стипендіальної винагороди досягнень студентів вищої школи України. Визначена необхідність при призначенні стипендій враховувати навчальні, позанавчальні досягнення студентів, а також мотиваційні освітні чинники, забезпечуючи за таких умов десуб'єктивізацію самого процесу призначення стипендій. Надано уявлення про особливості розподілу стипендіального фонду на прикладі Донбаської державної машинобудівної академії (ДДМА). Розглянуто процес прийняття рішень з призначення спеціальних стипендій в умовах неоднозначності якісних і кількісних критеріїв оцінки. Наведена формалізація процесу розподілу академічних стипендій з використанням теорії нечітких множин. Стипендії представлені у вигляді альтернативних ситуацій, до кожної з яких віднесена певна величина рейтингу потенційного претендента на отримання стипендії. До чинників, що впливають на вибір претендента, належать успішність, результати громадської і наукової діяльності. Для кожного заданого чинника визначені лінгвістичні змінні, задані на п'ятирівневій терм-множині, для опису яких використані трапецієвидні функції приналежності. Описано результати апробації запропонованої методики на прикладі кафедри інтелектуальних систем прийняття рішень ДДМА. Виконана нечітка класифікація чинників і згортка отриманих рівнів класифікації в загальну оцінку рейтингу претендентів як середньозважене за всіма показниками, що беруть участь в оцінці, й за усіма якісними рівнями цих показників. У якості прикладу для кафедри інтелектуальних систем прийняття рішень ДДМА сформований список претендентів на отримання іменних стипендій згідно із запропонованою авторами процедурою. Виконана комп'ютерна реалізації методики розподілу спеціальних академічних стипендій у вигляді програмного модуля web-системи кафедри.

Ключові слова: стипендіальний фонд; оцінка навчальних і позанавчальних досягнень студентів; задача нечіткої формалізації; призначення стипендій; нечіткі множини; web-додаток.

НЕЧЕТКАЯ ФОРМАЛИЗАЦИЯ И АВТОМАТИЗАЦИЯ ПРОЦЕССА РАСПРЕДЕЛЕНИЯ СПЕЦИАЛЬНЫХ АКАДЕМИЧЕСКИХ СТИПЕНДИЙ В ВЫСШЕМ УЧЕБНОМ ЗАВЕДЕНИИ

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Аннотация. В статье поставлена актуальная задача эффективного распределения стипендиального фонда при формировании бюджетной политики высшего учебного заведения Украины. Проанализирована практика распределения стипендиального фонда высших учебных заведений, описаны существующие формы стипендиального вознаграждения достижений студентов высшей школы Украины. Определена необходимость при назначении стипендий учитывать учебные, внеучебные достижения обучающихся, а также мотивационные образовательные факторы, при этом обеспечивая десубъективизацию самого процесса назначения стипендий. Дано представление об особенностях распределения стипендиального фонда на примере Донбасской государственной машиностроительной академии (ДГМА). Рассмотрен процесс принятия решений по назначению специальных стипендий в условиях неоднозначности качественных и количественных критериев оценки. Приведена формализация процесса распределения академических стипендий с использованием теории нечетких множеств. Стипендии представлены в виде альтернативных ситуаций, каждой из которых присвоена своя величина рейтинга потенциального претендента на получение стипендии. К факторам, влияющим на выбор претендента, отнесены успеваемость, результаты общественной и научной деятельности. Для каждого заданного фактора определены лингвистические переменные, заданные на пятиуровневом терм-множестве, для описания которых использованы трапециевидные функции принадлежности. Описаны результаты апробации предложенной методики на примере кафедры интеллектуальных систем принятий решений ДГМА. Выполнены нечеткая классификация факторов и свертка полученных уровней классификации в общую оценку рейтинга претендентов как средневзвешенное по всем участвующим в оценке показателям и по всем качественным уровням этих показателей. В качестве примера для кафедры интеллектуальных систем принятия решений ДГМА сформирован список претендентов на получение именных стипендий согласно предложенной авторами процедуре. Выполнена компьютерная реализации методики распределения специальных академических стипендий в виде программного модуля web-системы кафедры.

Ключевые слова: стипендиальный фонд; оценка учебных и внеучебных достижений студентов; задача нечеткой формализации; назначение стипендий; нечеткие множества; web-приложение.