Виділені специфічні особливості задач управління кваліфікованими людськими ресурсами (УКЛР), що ідентифікують їх як завдання багатокритеріального аналізу і прийняття рішень в нечіткому середовищі. Запропоновано модель прийняття рішень в задачах УКЛР. Обґрунтовано, що для підвищення ефективності та прозорості рішень в УКЛР доцільно застосування багатокритеріальної оптимізації на базі TOPSIS і показані його переваги

Ключові слова: управління контентом, людські ресурси, рекрутинг, прийняття рішень, нечітке середовище, нечіткі множини

Выделены специфические особенности задач управления квалифицированными человеческими ресурсами (УКЛР), позволяющие идентифицировать их как задачи многокритериального анализа и принятия решений в нечеткой среде. Предложена модель принятия решений в задачах УКЛР. Обосновано, что для повышения эффективности и прозрачности решений в УКЛР целесообразно применение многокритериальной оптимизации на базе TOPSIS и показаны его преимущества

Ключевые слова: управление контентом, человеческие ресурсы, рекрутинг, принятия решений, нечеткое среда, нечеткие множества

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A METHOD FOR CONSTRUCTING RECRUITMENT RULES BASED ON THE ANALYSIS OF A SPECIALIST'S COMPETENCES

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1. Introduction

Under conditions of active development of innovative information technologies and software development, human resources (IT-professionals) are turning into the main strategic resource of organizations [1], which ensures their long-term competitiveness and achievement of goals, set by the organization [2]. Therefore, development of new conceptual approaches to recruiting IT-professionals is becoming increasingly important and relevant [3]. Recruitment is the process of searching for and selecting personnel for vacant positions in the staff of a company [4]. It is the main function and responsibility of human resources managers and recruiters [1]. Different approaches and information sources are used for recruitment [5]. The main sources are the internal database of a company or an agency, websites for a job search, social capital (or searching for candidates among acquaintances), media, social networks, forums, blogs, etc., the employees of companies-competitors (attracting professionals from other companies), higher educational establishments (inviting young specialists from higher education institutions), and cooperation with recruiting agencies [6]. It is a multifaceted extensive subjective procedure, extended over time and dependent mainly on the level of training of recruiters [7].

2. Literature review and problem statement

As a rule, people who are not qualified or partially qualified in the field and the level of expertise required by the position that the candidates apply for are involved in the recruitment at the initial stages [8]. At the next stages, specialists in subject areas usually take part in job interviews in order to analyse the level of expertise of the applicants who have already been approved after the interview or testing at the initial stages [9]. But they spend a lot of time filtering the information about candidates and their competence [10]. All of this takes a lot of time and resources from companies that offer a job or recruitment companies (it is impossible to have specialists and experts in all possible fields) [11]. It is necessary to automate the partial sub-processes of analysis of expertise of candidates for the positions and to develop approaches to the analysis of the competence level of professionals [12]. Automation greatly reduces the time for selection of skilled workers and decreases the amount of data that need processing; it leads to a decrease in the subjectivity influence regarding recommendations of qualified people to the position. Taking into account the level of competences of applicants during recruiting makes it impossible to hire unqualified professionals [14].

Competences are the dynamic combination of knowledge, understanding, habits, abilities and skills [15]. Development of competences is the aim of training programs [16]. Competences are formed in a variety of academic disciplines and are evaluated at different stages [3].

Competences are divided into three types [2]:

A – Instrumental (cognitive, methodological, technological and linguistic abilities).

B – Interpersonal (communication skills, social interaction and cooperation).

C – System (combination of understanding, receptivity and knowledge, ability to plan changes for the improvement of systems, development of new systems).

In the European dictionary, the term "employability" (qualification for employment) is becoming increasingly popular; it describes the totality of knowledge, skills, habits, a good command of approaches to solving practical situations, as well as the ability and desire of continuous improvement and professional development [2]. Qualification for employment includes the following competences [17]:

– level of self-organization;
– ability to work in a group;
– ability to perform specific tasks;
– communication skills and literacy;
– knowledge of information technologies, etc.

We will note that these are so-called general competences that are independent of the main profile of a chosen profession.

Survey [2], conducted among European employers (mostly representatives of industry and business), demonstrated that the chances of getting a proper place in the labour market depends on:

– skills that characterize employability – 78 %;
– positive attitude to work –72 %;
– appropriate practical experience (internship) – 54 %;
– area of the obtained education and training – 41 %;
– level of academic achievement at a higher educational establishment the applicant graduated from – 28 %;
– name (prestige) of educational institution the applicant graduated from – 8 %.

3. The aim and tasks of the study

The aim of the work is the development of a multi-criteria optimization model of recruitment based on the analysis of competences of an IT-specialist. This will make it possible to automate the process of selection of IT-specialists in the recruitment departments of IT-companies through the development of appropriate software based on the developed model.

To achieve the aim, it was necessary to solve the following tasks:

– development of a formal model of classification of IT-professionals by the level of competence;
– development of the rules of competence evaluation of IT-specialists;
– development of the rules of recommendations for the positions of IT-specialists.

4. A formal model of recruitment based on the analysis of competences of an IT-specialist

Paper [2] contains a prioritized list of 31 competences ($K=\{k_1, k_2, ..., k_{31}\}$) according to the programme Tuning (Table 1). The priority is calculated by the method of hierarchy analysis (analytic hierarchy process, AHP) [18]. Each competence belongs to one of the criteria {A, B, C} [2].

Let us sort out the criteria of the K_i competence by categories (Table 1). For each category we will find coefficient of relative importance of criteria of competence w^i (as arithmetic mean of priorities of a category) [19]. Using the TOPSIS method [20, 21], we compute coefficients of relative importance of private criteria of competence w_j^i and the weight coefficients of private criteria of competence $w_j = w^i * w_j^i$ (Table 1) [22].

In the course of studying, the profile of distant student S is formed considering each level of competence K_S^A, K_S^B, K_S^C within [0;1]. A student is trained in certain specialty

$$P=\{p_1,p_2,...,p_{N_P}\}.$$

To acquire a specialty, it is necessary to complete several courses

$$C=\{c_1,c_2,...,c_{N_C}\} \text{ or } C_i^P=\{C_{i1}^P,C_{i2}^P,C_{i3}^P\}, \quad C_{ij}^P \subset C_i^P \subset C.$$

A course consists of disciplines

$$D=\{d_1,d_2,...,d_{N_D}\}.$$

Within each discipline, there are blocks of themes

$$L=\{l_1,l_2,...,l_{N_L}\} \text{ or } L_i^D=\{L_{i1}^D,L_{i2}^D,L_{i3}^D\}, \quad L_{ij}^D \subset L_i^D \subset L,$$

so

$$K_i \to (D_{i1},D_{i2},...,D_{in_i}) \text{ or } K_i \to (D_{i1},D_{i2},...,D_{in_i})$$

it is the choice of an expert group, which develops professional educational program. For each D_{ij}, a group of experts determines weight σ_{ij} for competence K_i ($\sum_j^{n_i}\sigma_{ij}=1$) using the AHP method [23]. For each C_i we construct a table of relationship between program competences and components of educational programs of a particular specialily (columns contain the list of disciplines, lines contain the list of competences). For example, for specialty 124 "Systems analysis" [24], the expert group defined 48 disciplines with the set of 28 competences and described the relationship between program competences and components of the educational program of a particular specialty. Each cell of this table is the presence or absence of a particular competence in a particular discipline. Accordingly, the matrix of weights of disciplines for the list of competences from the Tuning program is plotted.

$$\Omega=\begin{bmatrix} \sigma_{11} & \sigma_{12} & ... & \sigma_{1N} \\ \sigma_{21} & \sigma_{12} & ... & \sigma_{2N} \\ ... & ... & ... & ... \\ \sigma_{31,1} & \sigma_{31,2} & ... & \sigma_{31,N} \end{bmatrix}. \quad (1)$$

Table 1

Coefficients of relative importance of criteria received by AHP and TOPSIS

Type	Interpretation of criterion	K_i	Vector of priorities by AHP	w^i	w_j^i	$w_j = w^i * w_j^i$
	Ability to communicate in another language	k_1	0,081728		0.30812	0.130369
	Ability to communicate orally and in writing in native language	k_3	0,081728		0.223483	0.094558
	Ability to plan time and control it	k_5	0,073083		0.156996	0.066427
	Ability to search for, process and analyze information from different sources	k_8	0,056095		0.108416	0.045872
A	Ability to identify, formulate and solve problems	k_{10}	0,046394	0.423112	0.074296	0.031436
	Ability to make well- grounded decisions	k_{12}	0,036574		0.050915	0.021543
	Knowledge and understanding of subject area and understanding of specialty	k_{15}	0,026993		0.03516	0.014877
	Ability to think abstractly, analyze and synthesize	k_{19}	0,015431		0.0247	0.010451
	Skills of using information and communication technologies	k_{27}	0,005086		0.017915	0.00758
	Ability to be critical and self-critical	k_4	0,073083		0.286411	0.086828
	Ability to demonstrate awareness of equal opportunities and gender issues	k_6	0,064504		0.217059	0.065803
	Safety orientation	k_9	0,04951		0.156114	0.047327
	Ability to work in a team	k_{14}	0,028866		0.110389	0.033465
	Ability to work in international context	k_{16}	0,024721		0.077361	0.023453
B	Ability to act based on ethical considerations	k_{17}	0,020154	0.303159	0.054062	0.016389
	Ability to communicate with non-specialists of the same area	k_{18}	0,016523		0.037886	0.011485
	Interaction and interpersonal skills	k_{21}	0,011812		0.02679	0.008122
	Ability to act with social responsibility and civic consciousness	k_{23}	0,009635		0.019496	0.00591
	Focusing on preservation of environment	k_{28}	0,004351		0.014431	0.004375
	Ability to learn	k_2	0,081728		0.334658	0.091605
	Ability to produce new ideas (creativity)	k_7	0,06124		0.262228	0.071779
	Ability to apply knowledge in practical situations	k_{11}	0,041715		0.206098	0.056414
	Ability to conduct research at the appropriate level	k_{13}	0,032705		0.152891	0.04185
	Entrepreneur spirit	k_{20}	0,013559		0.11133	0.030474
	Ability to design and manage projects	k_{22}	0,011796		0.080632	0.022071
C	Certainty and perseverance in performing received tasks and responsibilities	k_{24}	0,008331	0.273726	0.058299	0.015958
	Correct understanding and respect for multiculture and differences	k_{25}	0,007182		0.042696	0.011687
	Ability to work independently	k_{26}	0,005859		0.031049	0.008499
	Ability to adapt to new situations	k_{29}	0,00363		0.023825	0.006522
	Ability to evaluate and maintain the quality of completed work	k_{30}	0,003158		0.017331	0.004744
	Ability to motivate people and to move towards common goals	k_{31}	0,002823		0.013621	0.003728

Because of the lack of professional expert studies of the relationship between program competences from the Tuning program (Table 1) and the components of educational program of a particular specialty, in this paper we assume that σ_{ij} are equal among themselves and $\sum_{j}^{n_i}\sigma_{ij} = 1.$

Analyzing the obtained weights of disciplines, the expert group estimates the weight of semesters or courses $c_1^e, c_2^e, ..., c_{n_c}^e$ $(\sum_{j=1}^{n_c} c_j^e = 1)$ at $D_j \in c_i^e$.

The set R contains specific learning outcomes by the theme blocks

$$R = \{r_1, r_2, ..., r_{N_R}\} \text{ or } R_i^L = \{r_{i1}^L, r_{i2}^L, ..., r_{iN_{LR}}^L\},\ R_{ij}^L \subset R_i^L \subset R$$

or by disciplines D_i. G are the learning outcomes by the category of competence at

$$G = \{G^A, G^B, G^C\},\ \ G = \{g_1, g_2, ..., g_{N_G}\},$$
$$G_i^D = \{G_D^A, G_D^B, G_D^C\}. \quad (2)$$

$$G^A=\{g_1,g_2,...,g_m\},\ \ G^B=\{g_{m+1},g_{m+2},...,g_{m+n}\},$$
$$G^C=\{g_{m+n+1},g_{m+n+2},...,g_{N_G}\}. \tag{3}$$

$$G_D^A\subset G_i^D\subset G,\ \ G_D^B\subset G_i^D\subset G,\ \ G_D^C\subset G_i^D\subset G. \tag{4}$$

$$G_D^A\subset G^A\subset G,\ \ G_D^B\subset G^B\subset G,\ \ G_D^C\subset G^C\subset G. \tag{5}$$

$$G_D^A=\{g_1^D,g_2^D,...,g_{m_D}^D\},\ \ G_D^B=\{g_{m_D+1}^D,g_{m_D+2}^D,...,g_{m_D+n_D}^D\},$$

$$G_D^C=\{g_{m_D+n_D+1}^D,g_{m_D+n_D+2}^D,...,g_{N_{GD}}^D\}. \tag{6}$$

Fig. 1 displays tree of analysis of relationship between courses, disciplines, themes and learning outcomes.

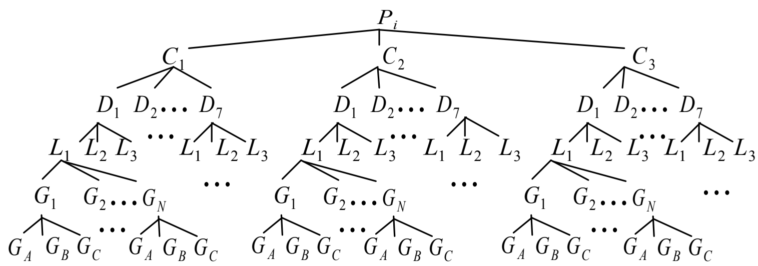

Fig. 1. Hierarchy of analysis of learning outcomes and the level of competences

$R_{ij}^D\subset R_i^D\subset R$ for discipline D_i of students (expert assessment) is assessed by the ECTS scale (Table 3). For a more accurate assessment of a student's level of competence, fuzzy trapezoidal numbers R^O are used in the TOPSIS method. In the course of finding trapezoidal fuzzy numbers, correspondence between the ECTS scale and numeric grades was used, which is presented in Table 2.

Next, we find weights of competences for particular student S_i

$$\overrightarrow{\lambda_s^e}=\Omega c^e\overrightarrow{R^o} \tag{7}$$

and a student's rating by the levels of acquired competences

$$\chi(S_i)=\sum\lambda_s^e.$$

To analyze learning outcomes of student S_i, we calculate his level of competence through the calculation of R^i and G^i by the defined set of characteristics α^S within [0;100] (Table 3).

Then we normalize $R_S^i\to K_S^i$ within $[0;w^i]$, taking into account the weights of competences (Table 1). For example, K_S^A varies within [0;0.423112], K_S^B within [0; 0.303159] and K_S^C within [0; 0.273726]. An analysis of learning outcomes (α^S) will be performed with the use of the TOPSIS method and compared with α_i^j from Table 5, which presents the hierarchy of recommended key professions of IT profile and their criteria of importance. Column 3 contains results of calculation by the AHP. The limits of evaluation in case 1 – according to a general education assessment at higher education institutions considering factor of importance of position ($\alpha_i^1\cdot 100=50+50\cdot\sum_{j=1}^{i}p_j$), and in case 2 – taking into account the level of competence. Column "Assessment limits 1" was obtained considering the point scoring assessment of alternatives at higher education institution (that is, a student with total assessment for the entire period of studying, for example, 80,5 points, may qualify for all positions, starting with the 4th, whereas he can not qualify for the first 3 positions; to receive position 13, it is necessary to be assessed within [50; 74.5287]). Column "Assessment limits 1" was obtained considering factor of importance by AHP (column 3 of Table 4). Column "Assessment limits 2" was obtained without considering significance by AHP ($\alpha_i^2\cdot 100=50+(50/15)(i-1)$).

Table 2

Linguistic values and corresponding fuzzy trapezoidal numbers

No.	Linguistic values	By ECTS	Fuzzy values	Grade R^i	Fuzzy trapezoidal numbers	Conditional sign
1	bad	F	0,15	0–25	(0,0,1,2)	1
2	unsatisfactory	FX	0,35	26–49	(1,2,2,3)	2
3	sufficient	E	0,55	50–60	(2,3,4,5)	4
4	satisfactory	D	0,65	61–70	(4,5,5,6)	6
5	good	C	0,75	71–79	(5,6,7,8)	8
6	very good	B	0,85	81–87	(7,8,8,9)	9
7	excellent	A	1	88–100	(8,9,10,10)	10

Table 3

Rules for the formation of competency profile of student

Course	Discipline	Theme	R_S^A	R_S^B	R_S^C	Learning outcomes
C_i	D_j	L_k	R_{ijk}^A	R_{ijk}^B	R_{ijk}^C	$G_{ijk}=\frac{1}{3}(R_{ijk}^A+R_{ijk}^B+R_{ijk}^C)$
		L_{k+1}	R_{ijk+1}^A	R_{ijk+1}^B	R_{ijk+1}^C	$G_{ijk+1}=\frac{1}{3}(R_{ijk+1}^A+R_{ijk+1}^B+R_{ijk+1}^C)$
		L_{k+2}	R_{ijk+2}^A	R_{ijk+2}^B	R_{ijk+2}^C	$G_{ijk+2}=\frac{1}{3}(R_{ijk+2}^A+R_{ijk+2}^B+R_{ijk+2}^C)$
Learning outcomes			$G_{ij}^A=\frac{1}{k}\sum_k R_{ijk}^A$	$G_{ij}^B=\frac{1}{k}\sum_k R_{ijk}^B$	$G_{ij}^C=\frac{1}{k}\sum_k R_{ijk}^C$	Analysis of results α^S*100

Table 4 displays an approximate list of common positions in IT-cluster in Ukraine. Outside Ukraine (for instance, in the EU), this list is much wider. The list was formed and sorted based on the results of a survey of representatives of IT-cluster in Lviv. At present, much to our regret, there are no clearly formulated general requirements to each of the listed positions. Each company determines the range of qualifications for each of the enumerated positions. For example, in some of them, to take up the position of Programmer, it is sufficient to know one of the programming languages, and to take the position of Software Engineer, an applicant must know the basics of algorithmization. The position of Student was introduced to the table conditionally, in order to indicate minimum conditions for making recommendations for further positions. In Ukraine, according to the requirements of Ministry of Education and Science, postgraduate training requires higher qualification than that for other positions in IT-cluster. If recommendations for positions numbered 2–7 allow IT-companies immediately and without any hesitation to hire recommended graduates, the recommendations for positions numbered 8–15 only register the possibility for a graduate to take such positions after appropriate internship and gaining experience at previous positions. Recommendation for position 10, for example, indicates only that a graduate can take positions 2–7 with the prospect of a career growth to position 10 inclusive with the competences acquired in the course of studying. In future he can qualify for higher positions under condition of development of his skills and competences.

Table 4

Coefficients of relative importance of the recommended basic IT-professions

No.	Position	Coefficient of importance by AHP p_i	Assessment limits	
			Case 1 – $\alpha_i^1 * 100$	Case 2– $\alpha_i^2 * 100$
1	Student	0	50	50
2	Assistant	0.007092	50.3546	53.33333
3	Tester	0.008599	50.78455	56.66667
4	Recruiter	0.011141	51.3416	60
5	Associate Software Engineer	0.014037	52.04345	63.33333
6	Administrator	0.018602	52.97355	66.66667
7	Programmer	0.023866	54.16685	70
8	Software Engineer	0.031904	55.76205	73.33333
9	Senior Software Engineer	0.041297	57.8269	76.66667
10	Team Leader	0.055204	60.5871	80
11	Associate Manager	0.071152	64.1447	83.33333
12	Manager	0.092353	68.76235	86.66667
13	Senior Manager	0.115327	74.5287	90
14	Senior Executive	0.142542	81.6558	93.33333
15	Systems architector	0.170746	90.1931	96.66667
16	Postgraduate	0.196136	99.9999	100

To run an analysis of learning outcomes and to make recommendations, we divide all students into 3 levels of training. In accordance with the value of the competence priority (Table 1), we divide the sorted list of competences into three parts (equal). The first 10 competences (A–5, B–3, C–2) belong to part I, the next 11 competences belong to part II (A–3, B–5, C–3), and the remaining 10 belong to part III (A–1, B–2, C–7). An analysis of the level of competence of a subject according to learning outcomes will be used to make the rules of recommendations for a position or a choice of occupations (Table 5, 6, β is analysis of competences according to learning outcomes).

Table 5

Rules of determining competence of student S for the analysis of competences according to learning outcomes (β)

level I	level II	level III
$\frac{1}{2}w^A < K_S^A \le w^A$ $0 < K_S^B \le \frac{1}{2}w^B$ $0 < K_S^C \le \frac{1}{2}w^C$	$\frac{1}{2}w^A < K_S^A \le w^A$ $\frac{1}{2}w^B < K_S^B \le w^B$ $0 < K_S^C \le \frac{1}{2}w^C$	$\frac{1}{2}w^A < K_S^A \le w^A$ $\frac{1}{2}w^B < K_S^B \le w^B$ $\frac{1}{2}w^C < K_S^C \le w^C$

Table 6

Rules of determining recommendations concerning professions of student S for the analysis of competences according to learning outcomes (β)

Rule	$\frac{1}{2}w^A < K_S^A \le \frac{3}{4}w^A,$ $0 < K_S^B \le \frac{1}{2}w^B,$ $0 < K_S^C \le \frac{1}{2}w^C$	$\frac{1}{2}w^A < K_S^A \le w^A,$ $0 < K_S^B \le \frac{1}{2}w^B,$ $0 < K_S^C \le \frac{1}{2}w^C$	$\frac{1}{2}w^A < K_S^A \le \frac{3}{4}w^A,$ $\frac{1}{2}w^B < K_S^B \le \frac{3}{4}w^B,$ $0 < K_S^C \le \frac{1}{2}w^C$
Position	2	3	4
Rule	$\frac{1}{2}w^A < K_S^A \le w^A$ $0 < K_S^B \le \frac{1}{2}w^B$ $\frac{1}{2}w^C < K_S^C \le \frac{3}{4}w^C$	$\frac{1}{2}w^A < K_S^A \le w^A$ $0 < K_S^B \le \frac{1}{2}w^B$ $\frac{1}{2}w^C < K_S^C \le w^C$	$\frac{1}{2}w^A < K_S^A \le w^A,$ $\frac{1}{2}w^B < K_S^B \le \frac{3}{4}w^B,$ $0 < K_S^C \le \frac{1}{2}w^C$
Position	5	6	7
Rule	$\frac{1}{2}w^A < K_S^A \le \frac{3}{4}w^A,$ $\frac{1}{2}w^B < K_S^B \le w^B,$ $0 < K_S^C \le \frac{1}{2}w^C$	$\frac{1}{2}w^A < K_S^A \le w^A,$ $\frac{1}{2}w^B < K_S^B \le w^B,$ $0 < K_S^C \le \frac{1}{2}w^C$	$\frac{1}{2}w^A < K_S^A \le w^A,$ $\frac{1}{2}w^B < K_S^B \le \frac{3}{4}w^B,$ $\frac{1}{2}w^C < K_S^C \le \frac{3}{4}w^C$
Position	8	9	10
Rule	$\frac{1}{2}w^A < K_S^A \le \frac{3}{4}w^A,$ $\frac{1}{2}w^B < K_S^B \le w^B,$ $\frac{1}{2}w^C < K_S^C \le \frac{3}{4}w^C$	$\frac{1}{2}w^A < K_S^A \le \frac{3}{4}w^A,$ $\frac{1}{2}w^B < K_S^B \le \frac{3}{4}w^B,$ $\frac{1}{2}w^C < K_S^C \le w^C$	$\frac{1}{2}w^A < K_S^A \le \frac{3}{4}w^A,$ $\frac{1}{2}w^B < K_S^B \le w^B,$ $\frac{1}{2}w^C < K_S^C \le w^C$
Position	11	12	13
Rule	$\frac{1}{2}w^A < K_S^A \le w^A,$ $\frac{1}{2}w^B < K_S^B \le \frac{3}{4}w^B,$ $\frac{1}{2}w^C < K_S^C \le w^C$	$\frac{1}{2}w^A < K_S^A \le w^A,$ $\frac{1}{2}w^B < K_S^B \le w^B,$ $\frac{1}{2}w^C < K_S^C \le \frac{3}{4}w^C$	$\frac{1}{2}w^A < K_S^A \le w^A,$ $\frac{1}{2}w^B < K_S^B \le w^B,$ $\frac{1}{2}w^C < K_S^C \le w^C$
Position	14	15	16

According to the example of Table 1, K_S^A ranges within $[0;w^A]$ ([0; 0.423112]), K_S^B – within $[0;w^B]$ ([0; 0.303159]) and K_S^C – with $[0;w^C]$ ([0; 0.273726]).

5. A formal model of IT-specialists classification by the level of competence

The process of making recommendations for a position or classification of IT-specialists by the level of their competence is described by superposition

$$R = \delta \circ \gamma \circ \beta \circ \alpha, \tag{7}$$

where sign $\circ$ means superposition of functions (output results of function α are the input date for function β, that is, it is a sequence of performing processes from the right to the left); α is the analysis of learning outcomes and compiling the rating by acquired competences; β is the analysis of competences according to learning outcomes; γ is the analysis of requirements for a position by the level of competences and learning outcomes; δ is making recommendations to a student/candidate regarding his profession according to statistics of studying and attainment of competences (δ_i^S is compared with $\delta_j(x_i)$; δ_i^S is calculated by learning outcomes of student S_i; $\delta(x_i)$ is the integral index, set within certain limits).

Integral index (coefficient of proximity of compared alternatives) $\delta(x_i)$, obtained on the basis of evaluation of these private criteria, expresses a certain value of a degree of chance of hiring every candidate x_i in the interval [0, 1]. The value of this magnitude allows making the final decision regarding each alternative candidate. In the process of conducting experiments connected with hiring an employee, we analysed the rules for choosing an alternative of recommendation for a position, according to the analysis of requirements for it (Table 7) [11].

A level of competence depends on the learning outcomes over a certain period (for example, 4 years of studying). Each period (year) may have its coefficient of importance according to the expert assessment. As a result of pairwise comparison of the importance of attainment of competences for each of the 4 years of training, the following values of coefficients of importance depending on the year of study were obtained for case I: e_1=0,375, e_2=0,125, e_3=0,125, e_4=0,375. Table 8 presents 5 cases (5 different opinions of different groups of experts) of distribution of coefficients of importance of competences for each year of studying out of 4.

As an example, we will analyze learning outcomes of any arbitrary 3 students (x_1, x_2, x_3) over four years for the purpose of their correspondence to 31 competences for the position of Senior Manager (position numbered 13 in Table 4). To do this, with the use of the TOPSIS method, we will calculate trapezoidal fuzzy numbers in Table 9, reflecting one of the equivalents of assessing a student's level of knowledge (Table 2).

According to Table 9, a student can score maximum 12400 points (31*4*100). For example, candidate x_1 scored 11160 points ($\delta_1^S = 11160 / 12400 = 0.9$ by general educational requirements for knowledge assessment), candidate x_2 scored 9080 ($\delta_2^S = 0.732258$), candidate x_3 scored 11160 ($\delta_3^S = 0.9$). Candidates x_1 and x_3 have the same number of points, but there is a difference in their level of training. Candidate x_1 studied better in the 1st year, worse – during the remaining years. x_3, on the contrary, studied worse at the beginning of training, but had better results in the end. That is why they have different levels of competences according to the chosen specialty. Special subjects are usually taught in senior courses. Accordingly, x_1 and x_3 have equal rights to claim for a position without taking into account their level of competence in all 31 criteria. Taking into account the competence of years of studying, a matrix of trapezoidal fuzzy numbers is plotted (Table 10). Table 10 also displays aggregated trapezoidal fuzzy numbers. Elements of the matrix of aggregated trapezoidal fuzzy numbers are multiplied by weights of private criteria and results are normalized (Table 11).

Table 7

List of alternatives of recommendations for selection of position

No.	Alternative	Candidate	Explanations concerning hiring
1	$\delta(x_i) \in [0; 0.25)$	does not meet requirements for the position	candidature is rejected
2	$\delta(x_i) \in [0.25; 0.50)$	hardly meets requirements	his hiring is a great risk
3	$\delta(x_i) \in [0.50; 0.65)$	partially meets requirements for the position	hiring is associated with insignificant risk, which can be compensated in the process of working by high indices of other competences
4	$\delta(x_i) \in [0.65; 0.80)$	meets requirements for the position	some indices can be easily filled in the process of adaptation
5	$\delta(x_i) \in [0.80; 1.00]$	fully meets requirements for the position	candidature is recommended

Table 8

Coefficients of competence according to year of studying

Pairwise comparison c_i^e	Variants of coefficients of importance of competences for each year of studying (cases)				
	I	II	III	IV	V
Year c_1^e	0,375	0.25	0.463184	0.413265	0.568093
Year c_2^e	0,125	0.25	0.275411	0.292222	0.287771
Year c_3^e	0,125	0.25	0.175972	0.186714	0.10758
Year c_4^e	0,375	0.25	0.085433	0.107799	0.036557

Table 9

Example of learning outcomes of students x_1 x_2 x_3

No.	Criteria	Alternatives	Expert assessment R_j^i				Matrix of trapezoidal fuzzy numbers R^O			
			c_1^e	c_2^e	c_3^e	c_4^e	c_1^e	c_2^e	c_3^e	c_4^e
1	k_1	x_1	A	A	B	B	(8,9,10,10)	(8,9,10,10)	(7,8,8,9)	(7,8,8,9)
		x_2	A	B	B	C	(8,9,10,10)	(7,8,8,9)	(7,8,8,9)	(5,6,7,8)
		x_3	B	B	A	A	(7,8,8,9)	(7,8,8,9)	(8,9,10,10)	(8,9,10,10)
2	k_3	x_1	A	A	B	B	(8,9,10,10)	(8,9,10,10)	(7,8,8,9)	(7,8,8,9)
		x_2	A	B	D	C	(8,9,10,10)	(7,8,8,9)	(4,5,5,6)	(5,6,7,8)
		x_3	B	B	A	A	(7,8,8,9)	(7,8,8,9)	(8,9,10,10)	(8,9,10,10)
3	k_5	x_1	A	A	B	B	(8,9,10,10)	(8,9,10,10)	(7,8,8,9)	(7,8,8,9)
		x_2	A	B	D	C	(8,9,10,10)	(7,8,8,9)	(4,5,5,6)	(5,6,7,8)
		x_3	B	B	A	A	(7,8,8,9)	(7,8,8,9)	(8,9,10,10)	(8,9,10,10)
....										
30	k_{30}	x_1	A	A	B	B	(8,9,10,10)	(8,9,10,10)	(7,8,8,9)	(7,8,8,9)
		x_2	A	B	D	C	(8,9,10,10)	(7,8,8,9)	(4,5,5,6)	(5,6,7,8)
		x_3	B	B	A	A	(7,8,8,9)	(7,8,8,9)	(8,9,10,10)	(8,9,10,10)
31	k_{31}	x_1	A	A	B	B	(8,9,10,10)	(8,9,10,10)	(7,8,8,9)	(7,8,8,9)
		x_2	A	B	B	C	(8,9,10,10)	(7,8,8,9)	(7,8,8,9)	(5,6,7,8)
		x_3	B	B	A	A	(7,8,8,9)	(7,8,8,9)	(8,9,10,10)	(8,9,10,10)

Table 10

Example of filling the matrix with aggregated trapezoidal fuzzy numbers with regard to competence of years of studying for case IV from Table 8

Criteria	Alternatives	Years of studying c_i^e				Aggregated trapezoidal fuzzy numbers
		c_1^e (e_1=0.413265)	c_2^e (e_2=0.292222)	c_3^e (e_3=0.186714)	c_4^e (e_4=0.107799)	
k_1	x_1	(3.30612, 3.719385, 4.13265, 4.13265)	(2.33778, 2.630002, 2.922225, 2.922225)	(1.306995, 1.493708, 1.493708, 1.680422)	(0.754593, 0.862392, 0.862392, 0.970191)	(0.754593, 2.176372, 2.352744, 4.13265)
	x_2	(3.30612, 3.719385, 4.13265, 4.13265)	(2.045557, 2.33778, 2.33778, 2.630002)	(1.306995, 1.493708, 1.493708, 1.680422)	(0.538995, 0.646794, 0.754593, 0.862392)	(0.538995, 2.049417, 2.179683, 4.13265)
	x_3	(2.892855, 3.30612, 3.30612, 3.719385)	(2.045557, 2.33778, 2.33778, 2.630002)	(1.493708, 1.680422, 1.867135, 1.867135)	(0.862392, 0.970191, 1.077991, 1.077991)	(0.862392, 2.073628, 2.147256, 3.719385)
k_3	x_1	(3.30612, 3.719385, 4.13265, 4.13265)	(2.33778, 2.630002, 2.922225, 2.922225)	(1.306995, 1.493708, 1.493708, 1.680422)	(0.754593, 0.862392, 0.862392, 0.970191)	(0.754593, 2.176372, 2.352744, 4.13265)
	x_2	(3.30612, 3.719385, 4.13265, 4.13265)	(2.045557, 2.33778, 2.33778, 2.630002)	(0.746854, 0.933568, 0.933568, 1.120281)	(0.538995, 0.646794, 0.754593, 0.862392)	(0.538995, 1.909382, 2.039648, 4.13265)
	x_3	(2.892855, 3.30612, 3.30612, 3.719385)	(2.045557, 2.33778, 2.33778, 2.630002)	(1.493708, 1.680422, 1.867135, 1.867135)	(0.862392, 0.970191, 1.077991, 1.077991)	(0.862392, 2.073628, 2.147256, 3.719385)
k_5	x_1	(3.30612, 3.719385, 4.13265, 4.13265)	(2.33778, 2.630002, 2.922225, 2.922225)	(1.306995, 1.493708, 1.493708, 1.680422)	(0.754593, 0.862392, 0.862392, 0.970191)	(0.754593, 2.176372, 2.352744, 4.13265)
	x_2	(3.30612, 3.719385, 4.13265, 4.13265)	(2.045557, 2.33778, 2.33778, 2.630002)	(0.746854, 0.933568, 0.933568, 1.120281)	(0.538995, 0.646794, 0.754593, 0.862392)	(0.538995, 1.909382, 2.039648, 4.13265)
	x_3	(2.892855, 3.30612, 3.30612, 3.719385)	(2.045557, 2.33778, 2.33778, 2.630002)	(1.493708, 1.680422, 1.867135, 1.867135)	(0.862392, 0.970191, 1.077991, 1.077991)	(0.862392, 2.073628, 2.147256, 3.719385)
....						
k_{30}	x_1	(3.30612, 3.719385, 4.13265, 4.13265)	(2.33778, 2.630002, 2.922225, 2.922225)	(1.306995, 1.493708, 1.493708, 1.680422)	(0.754593, 0.862392, 0.862392, 0.970191)	(0.754593, 2.176372, 2.352744, 4.13265)
	x_2	(3.30612, 3.719385, 4.13265, 4.13265)	(2.045557, 2.33778, 2.33778, 2.630002)	(0.746854, 0.933568, 0.933568, 1.120281)	(0.538995, 0.646794, 0.754593, 0.862392)	(0.538995, 1.909382, 2.039648, 4.13265)
	x_3	(2.892855, 3.30612, 3.30612, 3.719385)	(2.045557, 2.33778, 2.33778, 2.630002)	(1.493708, 1.680422, 1.867135, 1.867135)	(0.862392, 0.970191, 1.077991, 1.077991)	(0.862392, 2.073628, 2.147256, 3.719385)
k_{31}	x_1	(3.30612, 3.719385, 4.13265, 4.13265)	(2.33778, 2.630002, 2.922225, 2.922225)	(1.306995, 1.493708, 1.493708, 1.680422)	(0.754593, 0.862392, 0.862392, 0.970191)	(0.754593, 2.176372, 2.352744, 4.13265)
	x_2	(3.30612, 3.719385, 4.13265, 4.13265)	(2.045557, 2.33778, 2.33778, 2.630002)	(1.306995, 1.493708, 1.493708, 1.680422)	(0.538995, 0.646794, 0.754593, 0.862392)	(0.538995, 2.049417, 2.179683, 4.13265)
	x_3	(2.892855, 3.30612, 3.30612, 3.719385)	(2.045557, 2.33778, 2.33778, 2.630002)	(1.493708, 1.680422, 1.867135, 1.867135)	(0.862392, 0.970191, 1.077991, 1.077991)	(0.862392, 2.073628, 2.147256, 3.719385)

Table 11

Elements of normalized matrix of decision making

Criteria	Alternatives	Weight coefficient of criteria	Elements of weighed fuzzy matrix (*100)	Elements of normalized matrix of decision making
k_1	x_1	0.13037	(9.83756, 28.3731, 30.6725, 53.8769)	(0.18259, 0.52663, 0.56931, 1)
	x_2		(7.02683, 26.718, 28.4163, 53.8769)	(0.13042, 0.49591, 0.52743, 1)
	x_3		(11.2429, 27.0337, 27.9936, 48.4892)	(0.23186, 0.55752, 0.57731, 1)
k_3	x_1	0.09456	(7.13528, 20.5793, 22.2471, 39.0775)	(0.18259, 0.52663, 0.56931, 1)
	x_2		(5.09663, 18.0547, 19.2865, 39.0775)	(0.13042, 0.46202, 0.49354, 1)
	x_3		(8.15461, 19.6078, 20.304, 35.1698)	(0.23186, 0.55752, 0.57731, 1)
k_5	x_1	0.06643	(5.01254, 14.457, 15.6286, 27.452)	(0.18259, 0.52663, 0.56931, 1)
	x_2		(3.58038, 12.6834, 13.5488, 27.452)	(0.13042, 0.46202, 0.49354, 1)
	x_3		(5.72861, 13.7745, 14.2636, 24.7068)	(0.23186, 0.55752, 0.57731, 1)
………………………………				
k_{30}	x_1	0.00474	(0.35798, 1.03247, 1.11614, 1.96053)	(0.18259, 0.52663, 0.56931, 1)
	x_2		(0.2557, 0.90581, 0.96761, 1.96053)	(0.13042, 0.46202, 0.49354, 1)
	x_3		(0.40912, 0.98373, 1.01866, 1.76448)	(0.23186, 0.55752, 0.57731, 1)
k_{31}	x_1	0.00373	(0.28131, 0.81135, 0.8771, 1.54065)	(0.18259, 0.52663, 0.56931, 1)
	x_2		(0.20094, 0.76402, 0.81259, 1.54065)	(0.13042, 0.49591, 0.52743, 1)
	x_3		(0.3215, 0.77305, 0.8005, 1.38659)	(0.23186, 0.55752, 0.57731, 1)

Next, integral matrix of fuzzy ideal positive (best, x*) and fuzzy ideal negative (worst, x^-) decisions is plotted, which is presented in Table 12.

Table 12

Integral matrix of IPD and IND

Criteria of competence	x^*, IPD	x^-, IND
K_i	(1,1,1,1)	(0.130424, 0.130424, 0.130424, 0.130424)

Results of distances of alternatives to IPD, calculated by the value of each individual criterion, are presented in Table 13 (columns 2–4). Results of distances of alternatives to IND, calculated by the value of each individual criterion, are presented in Table 14 (columns 5–7).

Table 13

Distances of alternatives to IPD and by the value of each criterion

Criteria	$D(x_1,x^*)$	$D(x_2,x^*)$	$D(x_3,x^*)$	$D(x_1,x^-)$	$D(x_2,x^-)$	$D(x_3,x^-)$
k_1	0.26943	0.3084	0.24112	0.27712	0.261839	0.287144
k_3	0.26943	0.32552	0.24112	0.27712	0.249495	0.287144
k_5	0.26943	0.32552	0.24112	0.27712	0.249495	0.287144
………………………………						
k_{30}	0.26943	0.32552	0.24112	0.27712	0.249495	0.287144
k_{31}	0.26943	0.3084	0.24112	0.27712	0.261839	0.287144

Using the TOPSIS method, we will estimate the limits of criteria of competence and the level of competence for each of the three candidates. Taking into account the competences of years of studying, the matrix of trapezoidal fuzzy numbers is plotted, and aggregated trapezoidal fuzzy numbers are displayed. Elements of the matrix of aggregated trapezoidal fuzzy numbers are multiplied by weights of private criteria and the results are normalized. Then the integral matrix of IPD and IND, respectively, is plotted. For example, for case IV (Table 12), the limits of criteria of competence are [0.130424; 1] by the TOPSIS. Thus, for k_i when assessing IPD, we have x_1=0.51907, x_2=0.57054, x_3=0.49104. Distances of alternatives to IPD by the value of each individual criterion k_i are $D(x_1,x^*)$=0.26943, $D(x_2,x^*)$=0.32552 and $D(x_3,x^*)$=0.24112. For k_i, when assessing IND, we have x_1=0.526422, x_2=0.499494, x_3=0.535858. Distances of alternatives to IND by the value of each individual criterion k_i are $D(x_1,x^-)$=0.27712, $D(x_2,x^-)$=0.249495 and $D(x_3,x^-)$=0.287144.

We defined distances of each alternative to IPD and IND according to each variant of coefficients of importance for each year of studying (5 cases are considered as an example, see Table 8). Then we calculated values of integral index that expresses the degree of proximity of each compared alternative to the ideal solution by TOPSIS, and based on the results, the ranks of each alternative were determined (Table 14).

According to the obtained results, the best (optimum) option of decision in this case is IV, at which x_3, that is, candidate x_3, is an alternative. Chances of candidate x_3 are assessed by value $\delta_T^S(x_3)=0.521822$ when $\delta(x_3)\in[0.50; 0.65)$. The same concerns candidate x_2 ($\delta_T^S(x_2)=0.503516$ at $\delta(x_2)\in[0.50; 0.65)$), but he has a chance only if x_3 rejects the offer. Accordingly, hiring a candidate is associated with a low risk, which can be compensated in the process of work by high indices of other competences. As for candidate x_1 ($\delta_T^S(x_1)=0.470902$ at $\delta(x_1)\in[0.25; 0.50)$), hiring him is associated with greater risk.

Table 14

Distances of compared alternatives to IPD and IND, coefficient of their proximity to ideal solution and corresponding ranks by TOPSIS

Case from Table 9		Alter-natives	x^*	x^-	$x^* + x^-$	$\delta_T^S(x_i)$	Ranks
I	+ + –	x_1	2.697018	2.883112	5.58013	0.516675	1
		x_2	3.019768	2.730049	5.749817	0.474806	2
		x_3	2.697018	2.883112	5.58013	0.516675	1
II	+ – –	x_1	0.974359	2.41648	3.390839	0.71265	1
		x_2	1.845603	1.965006	3.810609	0.515667	2
		x_3	0.974359	2.41648	3.390839	0.71265	1
III	– – –	x_1	3.144922	2.979148	6.12407	0.486465	2
		x_2	3.346642	2.881048	6.22769	0.462619	3
		x_3	3.040106	3.007715	6.047821	0.497322	1
IV	+ + +	x_1	2.890055	2.930995	5.82105	0.503516	2
		x_2	3.149538	2.803118	5.952656	0.470902	3
		x_3	2.734	2.983532	5.717531	0.521822	1
V	– – –	x_1	3.534842	3.076006	6.610848	0.465297	1
		x_2	3.64263	3.01851	6.661141	0.453152	3
		x_3	3.526551	3.062903	6.589454	0.464819	2

6. Results of studies of the proposed approach to making recruitment suggestions based on the analysis of competences of IT-specialist

For objectivity of decision making, the experts carried out the point-scoring assessment of alternatives, closest to ideal decisions. To assess the alternatives, the correspondent calculations based on the point-scoring system of linguistic values according to Table 2 were carried out. On the basis of statistical data, obtained with the use of the point-scoring system of assessing alternatives, proximity of each alternative to the ideal decision by TOPSIS was established, with the component of 12400 points. Results of decision making on the basis of the point-scoring system of assessing three alternatives (candidates for a vacant position) are given in Table 15.

Table 15

Results of point-scoring assessment of alternatives

Alter-native	Total point – scoring assess-ment	Analysis of alternatives according to general edu-cational level of studying	Analysis of alternatives according to the calcula-tions by AHP and TOPSIS
x_1	11160	0.9	0.503516
x_2	9080	0.732258	0.470902
x_3	11160	0.9	0.521822

The best alternative is x_3, which scored 11160 points similar ti x_1, it is followed by priority by alternative x_2. According to the degree of proximity to the ideal decision, a correspondent conclusion is drawn for each alternative using a point– scoring system of assessment of alternatives:

1) x_1 ($\delta_K(x_1)$=0.9) – the candidate fully meets all the requirements for the position.

2) x_2 ($\delta_K(x_2)$=0.732258) – the candidate meets the requirements for the position under condition that some indices can be easily filled in in the process of adaptation.

3) x_3 ($\delta_K(x_3)$=0.9) – the candidate fully meets all the requirements of the position.

7. Discussion of results of exploring the approach to making suggestions for the recruitment through analysis of competences of a specialist

The obtained results of experimental calculations based on TOPSIS for the task of selecting the best candidate were compared with results of the selection, obtained using the point-scoring assessment system. Table 16 presents results of the two approaches to the estimation of the level of competence and the analysis of alternatives by the degree of proximity to the ideal decision regarding making recommendations for a conditionally selected position 13 (Table 4, Fig. 2), which allows conducting their comparative analysis.

Table 16

Results of priority of alternatives

Candi-date	Results based on AHP and TOPSIS	Results based on general educational scale of assessment	Data from Table 7	
			Case 1	Case 2
x_1	3	5	5	5
x_2	2	4	4	4
x_3	3	5	5	5

Comparison of results of the calculations with the use of two methods with regard to coefficients of relative importance of the basic recommended IT-professions (Table 4) reveals obvious discrepancy of the latter.

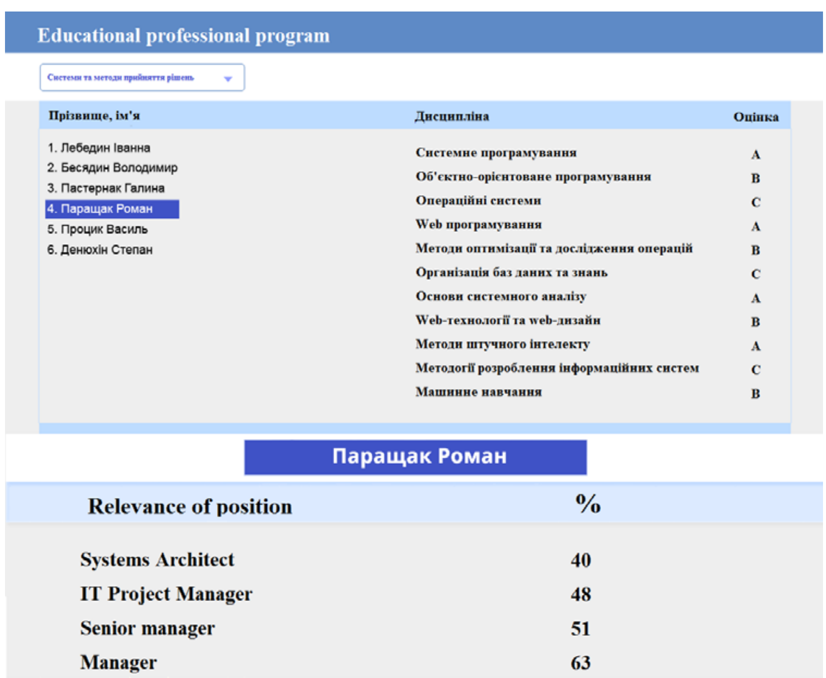

Fig. 2. Example of implementation of the calculation of coefficients of relative importance for the recommended basic IT-professions for a particular student

Moreover, those candidates whose hiring in accordance with the proposed method is associated with great risk, with the use of the point-scoring assessment of alternatives fall into the category of the most preferred. Thus, the results of testing show sufficient sensitivity of the TOPSIS method in the process of selection of the best alternative among the best, while the method of point-scoring assessment does not actually allow distinguishing among several most prioritized candidates by the degree of proximity to the ideal alternative. This proves the effectiveness of the proposed methodological approach when solving the tasks of MQHR.

8. Conclusions

1. As a result of the conducted studies, we developed a method for the classification of IT-professionals by the level of their competence based on their analysis for making recommendations and recruiting. Due to the fact that its special feature is the analysis of competences, sorted out by the specialists of IT-industry, and taking into account dependence of attained competencies and learning outcomes of a graduate in a particular specialty, the automation of the recruitment process for appropriate positions according to a student's learning results is ensured.

A general formal model for the classification of IT-professionals by the level of their competence was established and described. Its essence lies in a sequential analysis of the competence level of IT-specialist according to his learning outcomes in the chosen specialty. Thanks to it, recommendations for the positions in IT-industry are compiled according to the requirements of IT-cluster that automates the process of recruiting.

2. The matrix of influence of disciplines on competence was introduced. The rating of a specialist was defined based on the obtained grades in disciplines, coefficient of the year of studying a discipline and coefficient of importance of competences. The rules of evaluating the competence of IT-professionals were formed. They imply an analysis of the obtained weights of competences of a graduate from the comparison to the qualifications for the chosen positions, which makes it possible to compile a list of candidates for the recommended positions.

3. Based on the analysis of positions and required knowledge of the specialist, the rules of recruiting were formed, that is, the rules for recommendations for the positions of IT-specialists. They imply a comparison of the qualification level of applicants by the attained competences taking into account the learning outcomes and the weights of years of studying and discipline of training, which allows automating the process of recruiting.

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