

DOI: 10.31319/2519-8106.1(54)2026.351043

UDC 519.6:658.3

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MODELS AND ALGORITHMS FOR RATING ASSESSMENT OF THE QUALIFICATION LEVEL OF IT SYSTEMS DEVELOPERS

МОДЕЛІ ТА АЛГОРИТМИ РЕЙТИНГОВОГО ОЦІНЮВАННЯ КВАЛІФІКАЦІЙНОГО РІВНЯ РОЗРОБНИКІВ ІТ СИСТЕМ

The paper presents methods and algorithms for the personnel rating assessment system, which determine the criteria for the professional abilities of employees, their personal qualities and promising opportunities. For the rating assessment of the qualification level of system specialists, it is necessary to take into account the features of functional responsibilities and the specifics of the tasks performed. Based on the factor-rating model, a formalized version of the calculation of rating points is proposed. A qualification-level classification for IT systems development specialists by categories and criteria is carried out. A system of scoring the level of qualification of specialists for each criterion is proposed. The ranges of the rating level for the corresponding qualification gradations are also determined. The need to apply different rating scores for employees and applicants for available vacancies is indicated.

Objective assessment of the level of qualification and performance not only allows the employee to have an idea of how the work performed by him was evaluated, but also significantly affects the motivation of his further work. The presence of such an assessment is of particular importance for

the formation of creative teams for the implementation of innovative projects in various fields of technical and economic activity.

Keywords: *personnel assessment algorithms, rating assessment criteria, assessment methods, certification, testing.*

В сучасних умовах кваліфікація та професійний рівень персоналу, його здібності та вміння генерувати креативні ідеї визначають успіх подальшого розвитку та стабільності роботи підприємства. На основі результатів аналізу досвіду країн з розвинутою економікою показано, що в більшості успішних компаній велика увага приділяється проблемам підбору та підвищення кваліфікаційного рівня персоналу, який в умовах глобалізації економіки стає їх стратегічним та інтелектуальним капіталом. Відповідно, оцінка і стан цього ресурсу, його можливості – найважливіша умова для ефективного управління організацією. У роботі представлено методи та алгоритми для системи проведення рейтингової оцінки персоналу за якими визначаються критерії професійних здібностей співробітників, їх особисті якості та перспективні можливості. Для рейтингової оцінки кваліфікаційного рівня спеціалістів систем необхідно враховувати особливості функціональних обов'язків та специфіку виконуваних завдань. На основі факторно-рейтингової моделі запропоновано формалізований варіант нарахування рейтингових балів. Проведено кваліфікаційно-рівневу класифікацію для спеціалістів із розробки ІТ систем за категоріями та критеріями. Запропоновано систему бальної оцінки рівня кваліфікації спеціалістів за кожним критерієм. Визначено також діапазони рівня рейтингової оцінки для відповідних кваліфікаційних градацій. Вказано на необхідність застосування різних рейтингових оцінок для працівників та претендентів на наявні вакансії.

Об'єктивне проведення оцінки рівня кваліфікації та результатів діяльності не тільки дає можливість працівникові мати уявлення про те, як було оцінено виконану ним роботу, а й значною мірою впливає на мотивацію його подальшої трудової діяльності. Наявність такої оцінки відіграє особливо важливе значення для формування творчих колективів із реалізації інноваційних проєктів в різних галузях техніко-економічної діяльності.

Ключові слова: *алгоритми оцінки персоналу, критерії рейтингової оцінки, методи оцінки, атестація, тестування.*

Problem's formulation

In modern conditions, the availability of qualified personnel is one of the main conditions for the effectiveness of the financial and economic activities of any organization. It is precisely on the qualifications and professional level of personnel, their abilities and skills to generate creative ideas that the success of the further development and stability of the enterprise depends. Therefore, most enterprises use various personnel assessment systems that determine the criteria for the professional abilities of employees, their personal qualities and prospective opportunities [1, 2]. An objective assessment of the level of qualification and performance not only allows the employee to have an idea of how the work performed by him was evaluated, but also significantly affects the motivation of his further work [3, 4]. The presence of such an assessment is of particular importance for the formation of creative teams for the implementation of innovative projects in various fields of technical and economic activity. In this regard, the development and improvement of methods and algorithms for certification systems and assessment of the qualification level of personnel is a rather relevant both scientific and applied problem.

Analysis of recent research and publications

Analysis of the experience of countries with developed economies shows that in most successful companies, great attention is paid to the problems of selecting and improving the qualification level of personnel, which in the context of economic globalization becomes their strategic and intellectual capital. Accordingly, the assessment and condition of this resource, its capabilities are the most important conditions for effective management of the organization. In this regard, a few scientific works are devoted to the further development of the methodology for assessing such an important resource of organizations. Thus, in work [5], an analysis of the problems of developing methods for assessing

human capital was conducted and approaches to determining its level were proposed. The importance of using personnel assessment methods and their significance for the effectiveness of company management was formulated in article [6]. A systematization of modern methods of personnel assessment in leading world companies and an analysis of the possibilities of their distribution and use in Ukraine are given in work [7]. Modern methods of personnel assessment and tools for its implementation are also considered in publication [8]. The advantages of personnel assessment for both the enterprise and the employee are disclosed in work [9]. The main criteria were formed, and the components of personnel assessment were characterized. The personnel evaluation process is presented.

The results of the justification of the choice of personnel assessment methods are published in the article [10] and a methodological approach to conducting such an assessment for service organizations is presented. The publication [11] substantiates the need to use effective labor productivity management tools based on personnel assessment systems: OKR, MBO, KPI. The advantages of the OKR system compared to other personnel assessment systems are presented. The features of the KPI approach for developing a system for assessing the level of training of the enterprise's personnel are presented in the work [12]. Solving the issues of forming a personnel assessment system at the enterprise using modern systems and technologies is considered in the work [13]. The results of a comparative analysis of the OKR and MBO personnel assessment systems are presented in the publication [14]. The features of the practical application of the OKR system and the issues of its effectiveness are considered in the works [15, 16].

The results of the analysis show that methods for assessing the qualification level of personnel in different sectors of economic activity have their own specific features [10].

Formulation of the study purpose

The purpose of this study is to build a mathematical model and substantiate the possibilities of using an appropriate algorithm to build a system of comprehensive rating assessment of the qualification level of software system developers using the factor-rating method.

Presenting main materials

The assessment of the qualification level of a software developer is usually based on a set of technical, analytical and communicative skills. The following competencies are proposed to be used as the basic criteria for forming a technical level assessment system:

- Knowledge of programming languages: level of proficiency in basic languages (C++, Java, Python, C#, JavaScript, etc.).
- Algorithmic thinking: ability to develop effective algorithms, optimize code.
- Architectural skills: understanding the principles of building software systems, design patterns.
- Working with databases: knowledge of SQL/NoSQL, data normalization, query optimization.
- Tools and environments: experience with IDE, version control systems (Git), CI/CD.
- Analytical thinking ability and ability to conduct research are proposed to be taken into account by the following criteria:
 - Requirements analysis: ability to interpret technical and business requirements.
 - System modeling: using UML, ER diagrams, mathematical models.
 - Assessment of task complexity: ability to predict resources and execution time.
 - Systematization of system development results: participation in scientific and technical conferences; publication of innovative solutions in scientific publications.

Organizational skills and the ability to establish communication with employees are proposed to be taken into account by the following indicators:

- Teamwork: experience in collective development, use of Agile/Scrum methodologies.
- Documentation: quality of technical documentation, clarity of comments in the code.
- Presentation of solutions: ability to explain technical solutions to both technical and non-technical audiences.

To assess the level of professional training, an important factor is the availability of practical experience in the implementation and implementation of applied developments, which it is proposed to be taken into account by the following components:

- Implemented projects: number and complexity of completed projects.

- Contribution to open projects: participation in open-source communities.
- Level of responsibility: experience in roles from developer to technical lead.
- Results of test tasks for candidates.

Personal qualities and ability to organize are proposed to be considered according to the following indicators:

- Self-education: ability to quickly master new technologies.
- Critical thinking: ability to assess risks and propose alternative solutions.
- Ethics and responsibility: adherence to the principles of academic and professional integrity.

– In accordance with the above analysis and taking into account the existing competencies, the qualification-level graduation of IT system development specialists can be presented by the data given in tabl. 1.

Table 1. Qualification level graduation of IT systems development specialists

Category	Criterion	№	Junior	Middle	Senior	Lead/Architect
Technical skills	Knowledge of programming languages	1	knowledge of programming language	confident command of 1–2 languages	in-depth knowledge of several languages	expert, defines standards
	Algorithms and data structures	2	performs simple tasks	optimization of simple algorithms	designing complex systems	choosing systems development strategies
	Systems architecture	3	follows instructions	designs modules	defines and designs system goals	forms architectural standards
	Working with the database	4	knowledge SQL	query optimization	circuit design	technology selection, scaling
Analytical skills	Requirements analysis	5	needs mentoring	independent analysis	identifies and analyzes risks	forms technical business strategies
	Modeling	6	uses well-known templates	UML/ER-charts	develops original models	implements modeling methodologies
	Systematization of results	7	conference abstracts	publications	scientific articles	academic degree
Communication	Teamwork	8	performs tasks	active participant	mentor in system implementation	leadership, team management
	Documentation	9	short comments	high-quality documentation of algorithms	full development documentation	defines documentation standards

Category	Criterion	№	Junior	Middle	Senior	Lead/Architect
	Presentation of solutions	10	explains the implemented solutions	justification of decisions	justification of complex concepts	speaks to business/customers
Practical experience	Implemented projects	11	academic/educational	commercial projects	implementation of real systems	strategic projects, integrations
	Participation in open source	12	no	minor contribution	active participant	community leader, library author
	Test task	13	implementation of a known method	implementation of the original algorithm	implementation of a new system template	justification of systems development strategy
Personal qualities	Self-education	14	learns under guidance	independently masters new technologies	constantly improving	identifies promising areas and technologies
	Critical thinking	15	implements the proposed solutions	offers improved solutions	assesses risks	makes strategic decisions
	Ethics	16	follows the rules	responsible	implements standards	forms a style of integrity

For rating assessment of the qualification level of IT systems development specialists, it is necessary to take into account the features of functional responsibilities and the specifics of the tasks performed. It is proposed to calculate rating points for each criterion from 1 to 9 points, depending on the level of qualification compliance in the range of values given in table 2.

A formalized version of calculating rating points for different levels of personnel training is proposed to be carried out for each category in accordance with the criteria given in Table 1 according to the following algorithm:

$$R_b = (b_{11} + b_{12} + \dots + b_{1m}) + (b_{21} + b_{22} + \dots + b_{2m}) + \dots + (b_{n1} + b_{n2} + \dots + b_{nm}) = \sum_{i=1}^n \sum_{j=1}^m b_{ij}, \quad (1)$$

where b_{ij} — score determined by the evaluation sheet.

The assessment of the qualification level of an employee (applicant) is carried out in points from 1 to 9 according to the criteria given in table 1 and is entered into the evaluation sheet (questionnaire) in accordance with the values given in tabl. 2.

Table 2. Rating assessment of the qualification level of specialists

Rating	Junior	Middle	Senior	Lead/Architect
The range of values for one criterion, points.	1–3	3–5	5–7	7–9
Membership value range, points.	15–48	48–80	80–112	112–144

The result of the calculation according to formula (1) determines the level of qualification of the specialist. In accordance with the data in tabl. 2, the ranges of the rating values for each level of training of IT system developers are determined as follows:

- Junior — 15—48 points;
- Middle — 48—80 points;
- Senior — 80—112 points;
- Lead/Architect — 112—144 points.

To increase the effectiveness of the proposed algorithm for assessing the qualification level of personnel, it is necessary to take into account the features of functional responsibilities and the specifics of the tasks performed in each category:

- Junior — technical skills (basic programming, algorithms) are more important;
- Middle — balance between technical and analytical skills;
- Senior — the importance of analytics and communication, architecture formation and development team organization is growing;
- Lead/Architect — the greatest emphasis on analytics and communication, as it defines strategy and interacts with the business.

Taking into account the above data, it is proposed to use a generalization of model (1) using weighting factors of importance of each category and each criterion to determine a more accurate rating assessment of the level of qualification of IT development specialists. In this case, the corresponding algorithms for calculating the weighted rating assessment of personnel qualifications using the factor-rating method [17] will be defined as follows:

$$R_g = \alpha_1(b_{11} + b_{12} + \dots + b_{1m}) + \alpha_2(b_{21} + b_{22} + \dots + b_{2m}) + \dots + \alpha_n(b_{n1} + b_{n2} + \dots + b_{nm}) = \sum_{i=1}^n \alpha_i \sum_{j=1}^m b_{ij}; \quad (2)$$

$$R_t = (\beta_{11}b_{11} + \beta_{12}b_{12} + \dots + \beta_{1m}b_{1m}) + (\beta_{21}b_{21} + \beta_{22}b_{22} + \dots + \beta_{2m}b_{2m}) + \dots + (\beta_{n1}b_{n1} + \beta_{n2}b_{n2} + \dots + \beta_{nm}b_{nm}) = \sum_{i=1}^n \sum_{j=1}^m \beta_{ij}b_{ij}, \quad (3)$$

where α_i, β_{ij} — weighting factors of the influence of each category and criterion on the assessment of the level of personnel qualification.

The expertly determined values of the weight coefficients of categories and criteria for each qualification level of company employees and candidates are given in tabl. 3 and 4, respectively. It should be noted that the rating assessment is usually carried out for each qualification level of company employees and job applicants separately.

Table 3. Weighting factors for categories

Category	Weighting coeff.	Junior	Middle	Senior	Lead/Architect	General /applicant
Technical skills	α_1	0.35	0.30	0.25	0.20	0.15
Analytical skills	α_2	0.20	0.20	0.25	0.25	0.25
Communication	α_3	0.15	0.20	0.20	0.25	0.2
Practical experience	α_4	0.20	0.20	0.20	0.15	0.25
Personal qualities	α_5	0.10	0.10	0.10	0.15	0.15

Table 4. Weighting coefficients by criteria

Category	Criterion	Weighting coeff.	Junior	Middle	Senior	Lead/Architect	General /applicant
Technical skills	Knowledge of programming lan-	β_{11}	0.13	0.10	0.09	0.07	0,05

Category	Criterion	Weighting coeff.	Junior	Middle	Senior	Lead/Architect	General/applicant
	guages						
	Algorithms and data structures	β_{12}	0,08	0,07	0,06	0,04	0,03
	Systems architecture	β_{13}	0,07	0,06	0,05	0,05	0,04
	Working with the database	β_{14}	0,07	0,07	0,05	0,04	0,03
Analytical skills	Requirements analysis	β_{21}	0,07	0,07	0,11	0,10	0,09
	Modeling	β_{22}	0,08	0,07	0,08	0,08	0,08
	Systematization of results	β_{23}	0,05	0,06	0,06	0,07	0,08
Communication	Teamwork	β_{31}	0,05	0,07	0,07	0,09	0,07
	Documentation	β_{32}	0,05	0,06	0,06	0,07	0,05
	Presentation of solutions	β_{33}	0,05	0,07	0,07	0,09	0,08
Practical experience	Implemented projects	β_{41}	0,05	0,06	0,07	0,06	0,09
	Participation in open source	β_{42}	0,05	0,05	0,05	0,04	0,08
	Test task	β_{43}	0,10	0,09	0,08	0,05	0,08
Personal qualities	Self-education	β_{51}	0,03	0,03	0,03	0,04	0,04
	Critical thinking	β_{52}	0,03	0,03	0,03	0,05	0,05
	Ethics	β_{53}	0,04	0,04	0,04	0,06	0,06

Thus, we have obtained a sufficiently flexible assessment system in the form of a weighted rating, which more accurately reflects the level of qualification and takes into account not only points, but also the weight of competencies for each level. The calculation of the weighted rating is performed according to the corresponding algorithm (2) or (3) based on the data of the qualification level assessment sheet given in tabl. 5. It should be noted that the qualification level assessment sheet can be used as a universal questionnaire for certification or recruitment, as well as by employees for self-assessment.

Table 5. Qualification level rating assessment sheet

Category	Criterion	Points (1–9)	Weighting coeff.	Weighted score
Technical skills	Knowledge of programming language			
	Performs simple tasks			
	Follows instructions			
	Knowledge SQL			
Analytical skills	Needs mentoring			

Category	Criterion	Points (1–9)	Weighting coeff.	Weighted score
	Uses well-known templates			
	Conference abstracts			
Communication	Teamwork			
	Documentation			
	Presentation of solutions			
Practical experience	Implemented projects			
	Participation in open source			
	Test task			
Personal qualities	Self-education			
	Critical thinking			
	Ethics			
Total score				

Conclusions

This work analyzed the problems of increasing the efficiency of personnel rating evaluation, which should become one of the important factors in increasing the efficiency of the management process and ensuring the productivity and efficiency of companies. Modeling and implementing rating evaluation indicators allows you to objectively assess the level of qualification and results of personnel work and ensure that vacancies are filled by specialists with the necessary qualifications. Also, the use of indicators allows you to make the evaluation process more objective and systematic, which contributes to improving the quality of personnel work and the economic efficiency of the organization. Therefore, we can conclude that modeling metrics for assessing the effectiveness of adaptation of social enterprise employees is an important stage in personnel management, which can make a significant contribution to improving the quality of the enterprise's work and ensuring its success. For effective evaluation, it is advisable to use the methods proposed in the work in combination.

In the future, it is necessary to conduct research and generalize the above models and algorithms for rating personnel evaluation to be able to assess the qualification level of employees in other areas of economic activity.

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Надійшла до редколегії 11.12.2025

Прийнята після рецензування 17.12.2025

Опублікована 22.01.2026