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BUILDING AND DEVELOPING A PROJECT TEAM ON THE BASIS OF A MULTICRITERIA MODEL

The **subject matter** of the article is mathematical models for solving particular problems of selecting candidates for building a project team. The **goal** is to develop formalized models and methods for assessing the level of the generalized social and professional competence of each employee engaged at a specific type of work of an investment project while building and developing a project team. The **objectives** are: to formalize decision-making methods; to select the best option on the basis of multicriteria assessment and optimization methods; to analyze the peculiarities of multicriteria assessment tasks in the problems of human resource management; to apply mathematical models of decision making when selecting the most suitable candidates for the project on the basis of the general utility theory. The **methods** used are: multicriteria assessment and optimization methods, utility function. The following **results** are obtained. The general task of managing human resources and building a team for a new project was analyzed. The main criterion for involving candidates in the project team appeared to be the qualifications and experience of performing similar work accepted by the organization, but the impact of individual factors of a candidate should be also taken into account. Some methods for solving the task of multicriteria selection with the use of non-formalized experience applied to the tasks of managing the project labour resources are suggested. The suggested method of building a project team is based on the models of multicriteria optimization which, unlike available methods, enable taking into account not only professional competences of employees but also personal and psychological characteristics of candidates in various combinations, which contributes to qualitative performing project tasks depending on specifics requirements of the project. **Conclusions.** The task of selecting the most suitable candidates for the project on the basis of the general utility theory is considered. The competence approach to managing human resources is justified. The suggested model enables formalizing the preferences of decision-makers and obtaining objective numerical assessments of the competence of candidates. Thus, the task of building a project team is multicriteria and can be solved on the basis of multicriteria assessment and optimization methods. The questions of practical application of the proposed mathematical models and methods are considered. It is suggested to select candidates for a project team on the basis of their experience in solving similar tasks in previous projects.

Keywords: building a project team, project team, utility theory, multicriteria model, competence approach.

Introduction

Today almost every company constantly needs to build a high-quality professional and competent structure. Even if the company's activity is the efficient and stable process, it is necessary to pay attention to the tasks of the scientific normative justification of the methods of making personnel decisions.

Building a project team is one of the top priorities in the management of a modern project. At the stage of building a work collective project managers have to solve a number of specific tasks related to planning, implementing, control, responsibility, communication, the motivation of work, conflicts, power, leadership and so on.

Building and developing an efficient production team interacting as an integrated project team is a complex task that arises at three main levels: at the level of team management, at the level of social and psychological compatibility of the project team members and the manager, at the level of the performance of the specially built team that works as the team of like-minded colleagues.

Analysis of recent research and publications

According to the project management methodology (PMM) [1], the term "project management team" is defined as part of a project team that is responsible for project management such as initiating, planning, executing, monitoring, and completing various project phases.

Personnel selection is the process of selecting suitable candidates for involving in the project team according to the list of specialities, positions and trades that are planned according to the enterprise development plans and their predictable implementation in time.

The issues of building a work collective have been widely considered both in study materials and reference books. The variety of terms caused the necessity to structure the basic concepts associated with the process of hiring employees for an organization. The main terms and definitions of the analyzed sources are presented in table 1.

Defining the theoretical and practical value of available research, it can be noted that a certain range of issues on the target problem needs further development. This concerns the solution of the tasks of human resources management, including the assessment of applicants for vacancies.

The main results of the research

The concept of "team" is one of the key ones in project management as well as the terms "project team", "human resources management of the project" which include the processes of planning, team building, developing, transforming or disbanding [5].

The practice of personnel recruitment and disposition, professional advancement and development should be based on the objective, scientifically based appraisal of employees. The task of the employee's appraisal is to identify their labour potential, the degree of using this potential, to check if employees fit the positions they hold and whether they are prepared to hold another specific position [6].

Table 1. *Terminology associated with human resources management*

Source	Term	Definition
Project management dictionary (encyclopedia) [2]	Personnel selection	In the staff management, this term most often refers to the part of the hiring process associated with selecting one or more candidates to a vacant position among the total number of people applying for it. Generally, personnel selection should be regarded as a process of selecting a person from the total number of employees who meet the parameters according to the established criteria
	Talent acquisition	The set of organizational measures including all stages of staff involvement, as well as the selection of personnel and employment. Some specialists in the field of personnel management bring this process up to the end of the instatement stage, that is, they ensure that new employees are organically integrated into the specific work collective and in the organization as a whole
	Personnel recruitment	Recruiting a great number of people to any organization
Project Management Body of Knowledge PMBOK[1]	Project team recruitment	The process of confirming the availability of human resources and engaging the team necessary to carry out the operations of the project
A.Ya. Kibanov, I.B. Durakova [3]	Personnel recruitment	Engaging a great number of people to any organization
	Employment	A number of actions aimed at engaging candidates who have necessary qualities for achieving the goals set by the organization. This is a set of organizational activities, which includes all stages of employment, as well as assessing, selecting and recruiting personnel.
	Personnel selection	The process associated with selecting one or more candidates for a vacant position among the total number of people applying for it. This is the process of selecting a person from the total number of employees who meet established criteria using certain evaluation methods
N.A. Salomatin [4]	Employment	A number of actions aimed at engaging candidates who have necessary qualities for achieving the goals set by the organization
S.K. Mordovin [4]	Talent acquisition	The process of creating the database of employees of the required qualification to meet the organization personnel requirements
I.A. Nikitina [4]	Personnel recruitment	The system of measures taken by an organization to engage employees with necessary abilities, knowledge, skills and motivation the organization needs to achieve its goals and objectives
	Personnel selection	The process of selecting one (or more) candidate from a number of applicants who is the most advantageous according to the qualification criteria

Any organization is a functional organization [7]. According to the classical definition, an abstract structure is defined as an ordered set

$$S = MxR,$$

where M is a set of elements included in the system;

R is relations that are implemented at the elements of the sign x that is the Cartesian product that establishes the ordering relation.

Depending on the level of consideration, an element can be understood as an individual worker or as a team, a functional unit, organizational elements, and so on. The relations under consideration can be creative, organizational, informational, interpersonal, and so on.

When building production teams, the need arises to select specialists for performing certain types of work from the available list of candidates for a project according to their personal and psychological characteristics and features of the future work activity. Considering this circumstance, it is reasonable to assess candidates' personal and psychological characteristics separately followed by selecting them for work in the field that is the most suitable for them.

A number of works [8, 9, 10, 11] deal with the issues of formalizing decision-making methods on the basis of similarities in solving the tasks of management of

providing the staff to the processes of developing the enterprise and building the team of investment projects executors.

The method of selecting and assessing the personnel for the projects that are planned is based on the procedure for selecting candidates for a new project team from a number of people who performed similar works in successful projects of previous years [12]. The staff selected in this way is the basis for further differentiated assessment of each candidate to understand if they correspond to the content and features of a future work and have appropriate psychological (individual) personal characteristics.

The labour resources necessary to perform the planned work are determined according to the competence profile of employees. The quantity, qualifications and required level of training depend on the industry, the technology used, and the size of an enterprise. The competence approach while selecting personnel and assessing their professional qualities is based on the corresponding set of value criteria that enable the multi-criteria assessment of the professional level of candidates according to the selected list of criteria depending on the specificity of the project.

The method for assessing candidates for a project according to the professional, personal and psychological

set of relevant characteristics is built on the basis of the competence approach data, and a holistic (generalized) index of social professional competence is determined.

The membership of candidates for a project to be evaluated is formed at the pre-selection stage in terms of the proximity of the professional activity and the nature of the planned types of work. The selection and assessment of candidates are based on the general utility theory.

When determining the general social and professional competence [13] of an individual candidate, each block is considered separately by relevant experts who determine the list of characteristics and the methods of their usage for each competence block.

The structure of each competence $\langle K_1, K_2, K_3, K_4 \rangle$ is determined by a set of n_i of particular competences that have inherent value W_t:

$$0 \le W_{ti} \le 1, \ i = \overline{1,n}; \ \sum_{i=1}^{n} W_{ti} = 1,$$

where i is the index of an employee, t is the index of a competence.

The competence characteristics in each block are the levels of each candidate's competences b_i that are determined by corresponding specialists while testing

$$0 \le b_{it} \le 1, \ i = \overline{1,n}.$$

The overall competence of a specialist according to a particular block will be determined by the following equation:

$$f_t\left(\overline{b}\right) = \sum_{i=1}^{n} W_{it} b_{it}.$$

The candidate's competence is determined on the basis of the assessment of the utility function for each candidate and subsequent ranking a series of preferences [12].

The numerical values of assessing each candidate are determined by the value of the utility function, they are calculated according to the score of each characteristic from the set determined by experts.

$$S^P\left(K_i\right) = \sum_{j=1}^{m} b_j \mathrm{Y}^P_{H_j}, \text{ where } j = \overline{1,m},$$

where m is a number of test characteristics;

$\mathrm{Y}^P_{H_j}$ is the j-th standardized characteristic that is equal to

$$y^P_{Hj} = \frac{y^P_j - y^P_{jW}}{y^P_{jB} - y^P_{jW}},$$

$$0 \le \mathrm{Y}^P_{Hj} \le 1, \sum_{j=1}^{m} b_j = 1.$$

The ordered series is $S^P_1\left(k\right) \succ S^P_2\left(k\right) \succ \dots$

With regard to the procedure for assessing candidates for a project team, this can be interpreted as an individual assessment of each candidate according to professional, personal and psychological characteristics.

The generalized assessment of candidates according to professional, personal and psychological characteristics is determined by the value of the utility function [12]:

$$F\left(k_i\right) = C_1 P\left(k_i\right) + C_2 S^P\left(k_i\right) + C_3 S^{Ps}\left(k_i\right), \qquad (1)$$

where C_1, C_2, C_3 are the coefficients of the significance of professional $P\left(k_i\right)$, personal $S^P\left(k_i\right)$, and psychological $S^{Ps}\left(k_i\right)$ characteristics of candidates. The values of the coefficients of significance C_1, C_2, C_3 are formed by experts and decision makers $0 \le C_1 \le 1$, $0 \le C_2 \le 1$, $0 \le C_3 \le 1$; $C_1 + C_2 + C_3 = 1$.

After selecting candidates on the basis of proximity (3) and searching for similar works (2), the ranking list of candidates for a project according to the professional feature will be formed.

$$d^{(w)}_{pq} = \sqrt{\sum_{j=1}^{n} W_i^2 \left(x_{pj} - x_{qi}\right)^2} \qquad (2)$$

$$SM^W_{pq} = \frac{1}{1 + d^W_{pq}}. \qquad (3)$$

Thus, the scope of people who will be involved in the project team is determined after assessing their personal and psychological characteristics.

Candidates were selected and assessed on the basis of the general utility theory ty [12, 14]. Heterogeneous partial criteria are normalized according to the following formula:

$$k^H\left(x\right) = \left(\frac{k_i\left(x\right) - k_i^W\left(X\right)}{k_i^B\left(X\right) - k_i^W\left(X\right)}\right)^\alpha. \qquad (4)$$

The calculation of the generalized assessment of candidates according to the developed models and methods of building a project team, taking into account professional and personal psychological characteristics is presented in table 2.

The "worst" and "best" value of the ith partial criterion should meet the following requirements:

$$K_i^B = \max_{x \in X} K_i\left(x\right), \text{ if } K_i\left(x\right) \to \max;$$

$$K_i^B = \min K_i\left(x\right), \text{ if } K_i\left(x\right) \to \min.$$

$$K_i^W = \min_{x \in X} K_i\left(x\right), \text{ if } K_i\left(x\right) \to \max;$$

$$K_i^W = \max K_i\left(x\right), \text{ if } K_i\left(x\right) \to \min.$$

Table 2. *Calculation of the generalized assessment of candidates*

The list of experts	Criteria for assessment								
	Professional*			Personal*			Psychological*		
	Higher education (mechanical engineering or aviation)	Work experience in similar position at least 3-years	Software advanced user AutoCAD,Oracle, MathCAD, Teamcenter, Unigraphics NX 3,4.	Efficiency in insist on getting own way	Sociability	Leadership qualities	Quick acquisition of large amount of information	Quick adaptivity to a new environment	Psychological type is the extravert
Expert 1	2	1	2	1	1	2	0	1	0
Expert 2	1	1	1	2	2	1	1	0	0
Expert 3	2	2	1	0	1	1	1	1	0
Expert 4	1	1	1	1	1	1	1	1	1
Expert 5	1	1	1	1	1	1	1	1	0
Total	7	6	6	5	6	6	4	4	1
Specified weight	0,16	0,13	0,13	0,11	0,13	0,13	0,09	0,09	0,02
Possible deviation	0,15-0,17	0,12-0,14	0,12-0,14	0,10-0,12	0,12-0,14	0,12-0,14	0,08-0,10	0,08-0,10	0,01-0,03

*– P k_i are professional, S^P k_i are personal, S^{Ps} k_i are psychological characteristics of candidates.

The decision support system for human resource management offers the three most suitable candidates who scored the most points. Each factor listed in Table 3 corresponds to a 5-point scoring scale (weak level, needs improvement, sufficient level, good level, excellent level).

The integral assessment is calculated according to the formula (1).

Table 3. *Multicriteria assessment of candidates according to the generalized criterion*

The list of applicants	Criteria for assessment									
	Professional			Personal			Psychological			
	Higher education (mechanical engineering or aviation)	Work experience in similar position at least 3-years	Software advanced user AutoCAD,Oracle, MathCAD, Teamcenter, Unigraphics NX 3,4.	Efficiency in insist on getting own way	Sociability	Leadership qualities	Quick acquisition of large amount of information	Quick adaptivity to a new environment	Psychological type is the extravert	Integral assessment
Applicant 1	4	5	3	4	4	4	2	4	5	3,8
Applicant 2	5	3	4	3	5	4	1	3	4	3,6
Applicant 3	3	4	4	1	3	4	4	3	4	3,2

The architecture of the decision support system for human resources management enables increasing the reliability of the decisions made by increasing and detailing the initial information [13].

In addition, automation of the solved procedures enables increasing the efficiency of managing the procedure of making decisions in the tasks of multifactor assessment and optimization.

Conclusion

The problem of selecting the most suitable candidates for a project on the basis of the general utility theory is considered. The applicability of the competence approach in managing human resources is justified. The suggested model enables formalizing the decision-makers' preferences and obtaining objective numerical assessments of the competence of candidates. Thus, the task of building a project team is multicriteria and can be solved on the basis of the multicriteria assessment and optimization methods. The questions of practical application of the suggested mathematical models and methods are considered. The preliminary set of candidates for a project team is suggested to be developed on the basis of the experience in solving similar problems in previous projects.

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ФОРМУВАННЯ І РОЗВИТОК ПРОЕКТНОЇ КОМАНДИ НА ОСНОВІ БАГАТОКРИТЕРІАЛЬНОЇ МОДЕЛІ

Предметом вивчення в статті є математичні моделі для вирішення приватних завдань підбору кандидатів при формуванні команди проекту. **Мета** – розробка формалізованих моделей і методів оцінки рівня узагальненої соціально-професійної компетентності кожного виконавця в конкретному виді робіт інвестиційного проекту при формуванні і розвитку проектної команди. **Завдання:** формалізація методів прийняття рішень; вибір найкращого варіанту, на основі методів багатокритеріального оцінювання і оптимізації; аналіз особливостей завдань багатокритеріального оцінювання в задачах управління людськими ресурсами; застосування математичних моделей прийняття рішень при виборі найбільш підходящих кандидатів в проект на основі загальної теорії корисності. Використовуваними **методами** є методи багатокритеріального оцінювання і оптимізації, функція корисності. Отримані наступні **результати**. Проведено аналіз спільної справи управління трудовими ресурсами і формування команди нового проекту. Встановлено, що основним критерієм для включення кандидатів у проектну команду є прийнята в організації кваліфікація і досвід виконання подібних робіт, але також необхідно враховувати наявність і вплив індивідуальних факторів кандидата. Запропоновано методи розв'язання задачі багатокритеріального вибору з використанням неформалізованого досвіду в додатку до завдань управління трудовими ресурсами проекту. Запропонований метод формування команди проекту базується на основі моделей багатокритеріальної оптимізації, який на відміну від існуючих методів дозволяє враховувати не тільки професійні компетенції співробітників, але і особистісно-психологічні характеристики кандидатів в різних комбінаціях їх поєднань, що сприяє якісному виконанню командою проектних завдань в залежності від специфіки вимог проекту. **Висновки**. В роботі розглянуто задачу вибору прийняття рішень найбільш підходящих кандидатів в проект на основі загальної теорії корисності. Обґрунтовано доцільність застосування компетентнісного підходу в управлінні трудовими ресурсами. Запропонована модель дозволить формалізувати переваги ОПР, і отримати об'єктивні числельні оцінки рівня компетентності кандидатів. Таким чином, завдання формування команди проекту є багатокритеріальної і може вирішуватися на основі методів багатокритеріального оцінювання і оптимізації. Розглянуто питання практичного застосування запропонованих математичних моделей і методів. Формування попереднього безлічі кандидатів в команду проекту пропонується здійснювати на основі досвіду вирішення подібних завдань в попередніх проектах.

Ключові слова: формування команди проекту, проектна команда, теорія корисності, багатокритеріальна модель, компетентнісний підхід.

ФОРМИРОВАНИЕ И РАЗВИТИЕ ПРОЕКТНОЙ КОМАНДЫ НА ОСНОВЕ МНОГОКРИТЕРИАЛЬНОЙ МОДЕЛИ

Предметом изучения в статье являются математические модели для решения частных задач подбора кандидатов при формировании команды проекта. **Цель** – разработка формализованных моделей и методов оценки уровня обобщенной социально-профессиональной компетентности каждого исполнителя в конкретном виде работ инвестиционного проекта при формировании и развитии проектной команды. **Задачи:** формализация методов принятия решений; выбор наилучшего варианта, на основе методов многокритериального оценивания и оптимизации; анализ особенностей задач многокритериального оценивания в задачах управления человеческими ресурсами; применение математических моделей принятия решений при выборе наиболее подходящих кандидатов в проект на основе общей теории полезности. Используемыми **методами** являются методы многокритериального оценивания и оптимизации, функция полезности. Получены следующие **результаты.** Проведен анализ общей задачи управления трудовыми ресурсами и формирования команды нового проекта. Установлено, что основным критерием для включения кандидатов в проектную команду является принятая в организации квалификация и опыт выполнения подобных работ, но также необходимо учитывать наличие и влияние индивидуальных факторов кандидата. Предложено методы решения задачи многокритериального выбора с использованием неформализованного опыта в приложении к задачам управления трудовыми ресурсами проекта. Предложенный метод формирования команды проекта базируется на основе моделей многокритериальной оптимизации, который в отличие от существующих методов позволяет учитывать не только профессиональные компетенции сотрудников, но и личностно-психологические характеристики кандидатов в различных комбинациях их сочетаний, что способствует качественному выполнению командой проектных задач в зависимости от специфики требований проекта. **Выводы.** В работе рассмотрена задача выбора принятия решений наиболее подходящих кандидатов в проект на основе общей теории полезности. Обоснована целесообразность применения компетентностного подхода в управлении трудовыми ресурсами. Предложенная модель позволит формализовать предпочтения ЛПР, и получить объективные численные оценки уровня компетентности кандидатов. Таким образом, задача формирования команды проекта является многокритериальной и может решаться на основе методов многокритериального оценивания и оптимизации. Рассмотрены вопросы практического применения предложенных математических моделей и методов. Формирование предварительного множества кандидатов в команду проекта предлагается осуществлять на основе опыта решения подобных задач в предыдущих проектах.

Ключевые слова: формирование команды проекта, проектная команда, теория полезности, многокритериальная модель, компетентностный подход.