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METHOD OF PSYCHODIAGNOSTIC TOOLS' DETERMINATION FOR PROFESSIONAL SELECTION AND TRAINING OF SPECIALISTS IN COMPLEX ERGATIC SYSTEMS

The paper presents the results of scientific research in the field of engineering psychology regarding the creation of a method for selecting a set of psychodiagnostic techniques for the tasks of professional selection and training of specialists in complex ergatic systems. At the present stage, the process of professional selection of specialists of complex ergatic systems is standardized, but its individual components so far remain informal or subjective. This is especially true for the stages of building a specialist standard and the formation of an optimal set of psychodiagnostic techniques. The essential problems of professional selection of specialists are as follows. Most of the methods used to build the standard of specialty are characterized by significant subjectivity and directly depend on the qualifications of the expert who conducts the selection. None of the existing specialist models is universal and in the vast majority of cases has a narrow-profile nature. The lack of formalized models of psychodiagnostic techniques does not allow us to optimally select those that are necessary for the diagnosis of applicants, taking into account existing limitations and resources. When assessing the consistency of experts' opinions, the degree of their competence is not taken into account, which in practice can lead to distortion of the results. The solution of these problems will allow us to develop a system of automated support for building the standard of a specialist's specialty and to determine the specific psychodiagnostic techniques necessary for his professional selection. To do this, it is necessary to analyze the structure of professional selection, develop models of psychodiagnostic techniques and build a set of psychodiagnostic techniques, as well as a method for determining it relative to the constructed standards and available resources. The method of selection of a set of psychodiagnostic techniques for the tasks of professional selection and training of specialists of complex ergatic systems developed in the work can be used to automate the process of professional selection of professional workers of any specialization. The novelty of the proposed approach lies in formalizing the selection procedure for a set of diagnostic techniques as an optimization task. The developed set of algorithms made it possible to formalize the stages of choosing the optimal set of diagnostic methods in order to solve the problems of choosing the best method for a particular property and constructing a number of methods for a set of properties.

Keywords: *complex ergatic systems, specialists, method of professional selection of specialists, mathematical models, engineering psychology.*

Introduction

Problem statement. The main well-known theoretical and methodological works in professional selection of specialists in complex ergatic systems do not allow to assert the existence of a unified approach to systematization of knowledge on this issue [1–2]. Professional selection is a set of organizational activities and scientifically based methods and tools developed for selection of applicants. Those who turned out to be the most capable and fit professional activity in a certain field [3].

Professional selection should be considered as an integrated area of knowledge, based on the basic positions of mathematics, theory of management, decision making theory, psychophysiology, medicine, etc. Usually, the complex of professional qualifications consists of a medical and psycho-physiological examination, as well as a socio-psychological study of applicants [3]. It includes medical, educational, social, psychological and psychophysiological measures of selection with their own regulations, objectives, features of the methodology and methods of research, as well as a final conclusion [4].

So, we describe professional selection of specialists as an organized research process that allows using scientific methods to solve the following tasks:

- to identify professionally important qualities for specific activities of specialists and their correspondence with the regulated qualification characteristics;

- to detect and identify candidates who have the most suitable individual qualities, for learning, acquisition of professional skills and further activities in a complex ergatic system [5–6].

The result of this process is the integral assessment of the professional suitability of applicants given in the form of recommendations to the person who will make decisions regarding their employment.

Nowadays, the professional selection process of a specialist is standardized, but some of its components are still unstudied [6]. This is especially true for the stages of specialist standard creation and formation of an optimal set of psychodiagnostic tools. There are the following significant issues regarding the professional

selection of specialists:

1. Most of the methods used to create a specialist standard are characterized by significant subjectivism and are directly dependent on the qualifications of experts conducting the selection [3].

2. None of the existing models of a specialist is universal and, in most cases, has a narrow profile.

3. The lack of formalized models of psychodiagnostic tools does not allow optimal selection of tools necessary for the diagnosis of applicants, taking into account available constraints and resources.

4. In assessing agreement in experts' opinions, the degree of their competence is not taken into account, which in practice may result in distortion.

Research publications. The object of research in the professional selection is a person - an individual, as a subject of social relations and active labor activity. A person is endowed with features, qualities and abilities, allowing self-realization in society [7]. The basis for personal development is professional activity.

For example, psychology of labor determines a specialist as a professionally competent employee who possesses knowledge, skills, qualities and experience necessary for a qualitative and productive work [8]. Professional is a worker who has a certain competence, self-organization ability, responsibility and professional reliability together with knowledge, skills, and experience [2–3]. Formation of an employee as a professional includes two groups of factors: objective and subjective.

The most important components of specialist's activity are his qualities [1–2; 5]. Their development and integration in the process of professional formation lead to creation of a system of so-called professionally defining qualities (PDQ). PDQ is psychological and psychophysiological qualities of the personality that determine performance of activity (quality, efficiency, etc.) [8]. PDQ is divided into 4 main groups, which form structure of professional competence:

– features required to perform activities at the minimum permissible/normatively specified, average level (absolute PDQ);

– features that determine person's ability to achieve high quantitative and qualitative indicators of activity (relative PDQ);

– motivational availability to realize activity. High motivation can significantly compensate low level of many other PDQs (but not vice versa);

– features that contradict one or another kind of professional activity (anti-PDQ). Structure of professional suitability of the applicant involves either absence, or minimum level of anti-PDQ. In contrast to the first three groups' qualities, anti-PDQ meaningfully, but negatively correlates with the parameters of activity.

Combination of different types of PDQs is required while building a specialty standard. PDQ accounting reveals general and special abilities allowing to select types of activity that closely meet the requirements of the professional worker [9]. These suggestions make a basis for the models of modern specialist, which, however, do not help in formation of a specialist's standard [10 – 13].

All those models can be divided into two large groups: the first one – treating personality as a set of features, and the second one – treating personality as an integral system [14]. Such models are: personality as a set of features, personality as a set of coordinated features, personality as a component of the management system, personality as a transmission system, personality as an information consumer. But application of existing models of specialist in the process of professional selection is significantly limited.

The research aims and objectives. Models which are mathematically described do not consider the worker-professional in details. Models that describe personality closely are difficult to formalize. It complicates the process of professional selection and creation of its automated support systems. Application of existing models in order to build a specialist's standard does not allow decomposing features and presenting the model more clearly.

An integrated approach to assessing the professional suitability of a specialist includes study of the profession that is selected and psychological study of the applicant's personality. That is why the basis of algorithms and procedures for creation of the specialist's standard is the method of two portraits. Analysis of the specialist's features allows carrying psychological study of the personality of a specialist [15].

Solution of these problems will help to develop a system of automated support for creation of a specialist's standard and to determine the specific psychodiagnostic tools necessary for professional selection. To do this, we need to analyze the structure of professional selection and develop models of psychodiagnostic tools. Next we should select a set of psychodiagnostic tools, as well as create a method for its determination in accordance with developed standards and available resources.

So, at this stage, the main task of the study is development of a formalized model of psychodiagnostic tools. The main goal of the work is to develop a method for the complete set of psychodiagnostic tools for professional selection and training of specialists, taking into account the features of their activities.

Research bases

Generally, professional selection consists of the preparatory, assessment and final stages.

The preparatory stage can be divided into the following phases: formulation of goals and objectives for selection; definition of the range of necessary (those that must be tested) characteristics (features) and selection of a set of tests. The assessment stage has the following phases: definition of groups for professional selection; carrying out an automated testing; processing of results.

The final stage includes interpretation and discussion of test's results, as well as documentation.

The stage 1.1 (setting up of goals and objectives), specifies the main goal of professional selection, which is subsequently detailed and divided into separate tasks.

The stage 1.2 (creation of a specialist's standard) includes two phases: selection of the nomenclature of the required characteristics of the applicant and their assessment (ranking) in accordance with the purpose of professional selection [16].

The most critical in the whole process of professional selection is the definition of the PDQ nomenclature [3]. Reducing subjectivity when approving the most complete range of required characteristics requires inclusion of up to 4-5 specialists in the expert group, who are directly engaged in this work (professional workers) and 2-3 specialists of the management staff (managers-professionals).

The second part of the PDQ nomenclature formation is to determine the weighting coefficients of each of the obtained criteria, and the main difficulty is a correct reception of such coefficients [17].

Set of psychodiagnostic tools is developed at the stage 1.3. These tools help to test applicants' dominance of the characteristics taken from specialist's standard. It is important to choose tools that not only provide the most reliable result, but also satisfy the requirements for available resources.

The evaluation stage is currently the most worked out in terms of the possibility of automating the procedure for professional selection. However, the mechanical transfer of psychological tests to an automated basis without proper adaptation and testing leads to false decisions [18].

Interpretation of results (stage 3.1) and decision-making (stage 3.2) are the most creative stages. Therefore, they are virtually non-formalized and cannot be automated. So, we can see comparison of the results of the diagnosis with the standard at these stages. The decision on the suitability of an applicant should be made on the basis of delta-proximity, which can be quantitatively determined by one of the statistical methods [2; 19–20].

Documentation making process (stage 3.3) consists of the formation of various reports describing the entire procedure; justification of the diagnostic methods used; description of diagnosis' results and other information that facilitates decision-making.

The ultimate probability of correct diagnosis of applicants depends mainly on the assessment stage of professional selection of specialists. But from the research point of view the most interesting are the first (preparatory) and the third (final) stage. They are the most difficult ones for the automation process.

Within the preparation for testing, special attention should be paid to the definition of a set of psychodiagnostic tools that will help to obtain generalized characteristics for the surveyed group. The formalization of the modern presentation of methodology data is important to formulate the problem of optimal choice of psychodiagnostic tools.

If the base set $\Omega = \bigcup_{i=1}^{n} \omega_i$ – is a set of all possible psychological (psychophysiological) features that an individual can have. Each of these features is characterized by some tuple of individual characteristics:

$$\omega_i \Rightarrow b_i = \left\langle b_{i1}, b_{i2}, ..., b_{ik_i} \right\rangle . \quad (1)$$

If $B = \bigcup_{i=1}^{n} b_i$ – is a set of all possible psychological characteristics, the elements of which are separate components of the above tuples. Let's denote these components (partial characteristics) as c_j. Then we will have the ratio $B = \bigcup_{j=1}^{N} c_j$ where N is the total number of different characteristics.

We can use various psycho-diagnostic tools to check the degree of display for each of the psychological characteristics. They allow determining the severity degree of psychological features of an individual.

Let's use the following symbols:

T^{c_j} – set of psychodiagnostic tools that will check the displayed degree of the characteristics of c_j;

T^{b_i} – set of psychodiagnostic tools that will check the displayed degree of the features of b_i;

$T_c = \bigcup_{j=1}^{N} T^{c_j}$ – set of all possible tools that will check individual characteristics;

$T_b = \bigcup_{i=1}^{n} T^{b_i}$ – set of all possible tools that will check individual features.

It is assumed that there is some psychodiagnostic tool t. $C_t = \left\{ c_{t1}, c_{t2}, ..., c_{tk_t} \right\}$ – is a set of characteristics and $B_t = \left\{ b_{t1}, b_{t2}, ..., b_{tn_t} \right\}$ – is a set of features that can be verified using this tool.

Then the psychodiagnostic tool is fully described either by two separate tuples of the form $\left\langle c_{t1}, c_{t2}, ..., c_{tk_t} \right\rangle$ and $\left\langle b_{t1}, b_{t2}, ..., b_{tn_t} \right\rangle$, or by one common tuple $\left\langle c_{t1}, c_{t2}, ..., c_{tk_t}, b_{t1}, b_{t2}, ..., b_{tn_t} \right\rangle$, where k_t – is a number of characteristics, and n_t – is a number of features that can be verified using the tool t.

The developed formalized model of psychodiagnostic tools fully corresponds to the modern approach to

professional selection. However, it does not take into account resources required for the implementation of a specific tool, and does not ensure validity of the obtained results. The present model should serve as a basis for the elaboration of a generalized structural model of psychodiagnostic tool.

The quality of the psychodiagnostic tool is determined by the following indicators: reliability, ability to differentiate, etc. [15]. The task of professional selection is not only to choose applicants with individual characteristics satisfying certain requirements, but also those who will meet these requirements during a certain period of time in future. Therefore, it is necessary to use tools with high coefficients of current and prognostic validity during professional selection.

We use coefficient of validity, which varies from 0 to 1, as a quantitative characteristic of any type of validity. One tool in different samples may have different coefficients of validity [21]. Consequently, the probability of correct determination of the required characteristics cannot be high, because even a tool with a good coefficient of reliability and with an average indicator of one of validity types may not give the necessary accuracy of the result.

Let's introduce another characteristic to assess the quality of psychodiagnostic tool. It will determine the probability of accurate determination of one or another feature or set of features. At the same time, the new characteristic is constant and is calculated as a function depending on the validity and reliability coefficients:

$$p = V \times N, \qquad (2)$$

V – is a coefficient of predictive or current validity of psychodiagnostic tool,

N – is a coefficient of reliability of the present tool. Choice of the coefficient of validity type is determined according to the purpose of professional selection.

Then the generalized structural model of the psychodiagnostic tool will be the following:

$$M_t = \left\langle C_t, B_t, N_t, V_{C_t}, V_{B_t}, R_t \right\rangle, \qquad (3)$$

$C_t = \left\{ c_{t1}, c_{t2}, ..., c_{tk_t} \right\}$ – is a set of characteristics that can be diagnosed using a psychodiagnostic tool t;

k_t – is a number of characteristics that can be diagnosed using the tool t;

$B_t = \left\{ b_{t1}, b_{t2}, ..., b_{tn_t} \right\}$ – is a set of features that can be diagnosed using a psychodiagnostic tool t;

n_t – is a number of features that can be diagnosed by the tool t;

N_t – is a coefficient of reliability of psychodiagnostic tool t;

$V_{C_t} = (V(c_{t1}), V(c_{t2}), ..., V(c_{tk_t}))$ – is a vector of coefficients of validity for each of the characteristics diagnosed by psychodiagnostic tool t;

$V_{B_t} = (V(b_{t1}), V(b_{t2}), ..., V(b_{tn_t}))$ – is a vector of coefficients of validity for each of the features diagnosed by psychodiagnostic tool t;

$R_t = (r_1(t), r_2(t), ..., r_k(t))$ – is a vector of resources necessary to carry out the psychodiagnostic tool t.

Formalizing psychodiagnostic tools and introducing an additional set of characteristics will not only improve the quality of the results. It will also help to automate the process of creating a set of tools that optimally satisfy the existing constraints on different types of resources.

Let's assume that in a set of psychodiagnostic tools, all components identify specific characteristics with their subsequent integration in the features and portrait of the respondent.

We will also assume that all tools are used sequentially. Use of each resource is an additive function.

Using the developed formalized model of psychodiagnostic tool, we can describe a set of psychodiagnostic tools as follows:

$$Q_{\bar{t}} = \left\langle \bar{t}, C_{\bar{t}}, N_{\bar{t}}, B_{\bar{t}}, P_{\bar{t}}, V_{c_{\bar{t}}}, R_{\bar{t}} \right\rangle, \qquad (4)$$

$\bar{t}$ – is a vector of psychodiagnostic tools;

$C_{\bar{t}}$ – is a set of all characteristics diagnosed as a result of using the entire set of psychodiagnostic tools (it should be noted that in the majority of cases there is redundancy. Different tools of the set can diagnose the same characteristics);

$N_{\bar{t}}$ – is a coefficient of reliability for the set of psychodiagnostic tools that varies from 0 to 1.

We suggest a relatively simple method of $N_{\bar{t}}$ calculation assuming that the tools are used sequentially:

$$N_{\bar{t}} = \prod_{t=1}^{n} N_t, \qquad (5)$$

N_t – is a coefficient of reliability of psychodiagnostic tool t;

$B_{\bar{t}}$ – is a set of all features that are evaluated according to received characteristics;

$P_{\bar{t}}$ – is a vector of accurate probabilities determination by the tool of given characteristics (varies from 0 to 1);

$V_{c_{\bar{t}}}$ – is a validity vector for each of the characteristics, calculated according to the validity of all tools of the set for each of the characteristics (varies from 0 to 1);

$R_{\bar{t}}$ – is a vector of resources necessary for diagnostics done using a set of psychodiagnostic tools. The main components of the resource vector $R_{\bar{t}} = (L, T, S)$

are:

L – user-friendly vector for each tool (varies from 0 to 100);

T – average time spent on carrying out the entire set of psychodiagnostic tools. It is measured in minutes and is an additive function;

S – cost of a set of psychodiagnostic tools, calculated as a sum of the cost of all tools from the set.

Let's suppose that for the compilation of some psychological portrait A one must know some set of psychological features B (A), which, in turn, depend on a set of characteristics C (A). It should be noted that the sequence of correspondences $A \to B(A) \to C(A)$ is determined on the basis of modern psychological knowledge [15]. In this case, we can obtain estimates of different features based on knowledge of the same characteristics, taking into account the varying degrees of the characteristics' significance that are part of these features.

This suggests that the transformation $A \to B(A) \to C(A)$ is not mutually single-valued.

We will formulate the problem of unconstrained optimization for the choice of a set of psychodiagnostic tools (for different $i = 1, 2, ..., k$):

$$\min_{\bar{t},\, C(A) \subset C_{\bar{t}}} r_i(\bar{t}) \tag{6}$$

and constrained optimization:

$$\min_{\bar{t},\, C(A) \subset C_{\bar{t}}} r_i(\bar{t}) : r_1(\bar{t}) \le r_1, ..., r_k(\bar{t}) \le r_k . \tag{7}$$

If $V(A, \bar{t})$ is a coefficient of validity of a psychological portrait A, obtained by a set of psychodiagnostic tools $\bar{t}$. Then we can formulate a fundamentally new set of problems [17; 22–23]:

– unconstrained optimization (global extremum search):

$$\max_{\bar{t},\, C(A) \subset C_{\bar{t}}} V(A, \bar{t}) ; \tag{8}$$

– constrained optimization that arises when constructing a set of psychodiagnostic tools (for all $i = 1, 2, ..., k$):

$$\min_{\bar{t},\, C(A) \subset C_{\bar{t}}} V(A, \bar{t}) : r_1(\bar{t}) \le r_1, ..., r_k(\bar{t}) \le r_k . \tag{9}$$

Developed models, as well as formulated optimization tasks, are the basis for developing a method for choosing psychodiagnostic tools.

Those tools will verify the degree of severity of psychological or psychophysiological features for the purpose of professional selection and training of specialists in complex ergatic systems.

One of the main and most difficult tasks of professional selection is the choice of psycho-diagnostic tools that will give the most reliable result and correspond to available resources [18].

To solve this problem we define the following sets: X – is a set of characteristics $\{X_1, X_2, ..., X_n\}$; T – is a set of psychodiagnostic tools $\{t_1, t_2, ..., t_L\}$, each of which is intended to verify the degree of belonging of L characteristics to a subset $\{\omega_1, \omega_2, ..., \omega_L\}$, $\omega_i \in X$ [24 – 28].

If each of the characteristics can take several values (isolated or intersecting intervals), then we have

$$\bar{x}_1 = (x_{11}, x_{12}, ..., x_{1n_1})$$

.....

$$\bar{x}_N = (x_{N1}, x_{N2}, ..., x_{Nn_N}).$$

Now we can form a set of all possible combinations: $Y = \bar{x}_1 * \bar{x}_2 * ... * \bar{x}_N$.

At the same time, there is a transformation $Y \xrightarrow{Z} T$, where Z is the set of different, sometimes unformalized and partially contradictory rules and tools that the psychodiagnostic tools are based on. Obviously, this is a transformation of the set of characteristics Y_x to the set T_x.

It is also obvious that there is a transformation $T \xrightarrow{U} Y$ that should also be a transformation to the set Y_x.

The simplest task of professional selection is the choice of a tool (which partially diagnose the characteristic $\bar{x}_i$) from a certain set of psychodiagnostic tools $U^{-1}(\bar{x}_i) \in T$ that diagnose this characteristic.

Let's introduce the following set of indicators for each of the available psychodiagnostic tools:

$$S(t_g) = (\omega_{g_1}, ..., \omega_{gk_g}, P_{g_1}, ..., P_{g_{k_g}}, r_{g_1}, ..., r_{g_m}), \quad g = \overline{1, L}, \tag{10}$$

$\omega_{g_1}, \omega_{g_2}, ..., \omega_{g_{k_g}}$ – is the parameters that are determined;

$P_{g_1}, P_{g_2}, ..., P_{g_{k_g}}$ – is the probability of correct determination of the true values of these parameters;

$r_{g_1}, r_{g_2}, ..., r_{g_m}$ – resources that are necessary for carrying out a psychodiagnostic tool t_g, such as time of its implementation, cost, etc.

So, we can write:

$$S(t_g) = \bar{\omega}_g \cup \bar{P}_g \cup \bar{r}_g . \tag{11}$$

As a result, we have a generalized method for determining a set of psychodiagnostic tools for making professional selection and training of specialists considering the peculiarities of their activities (Fig. 1).

Let's describe the essence of the blocks of the proposed method in the sequence of procedures.

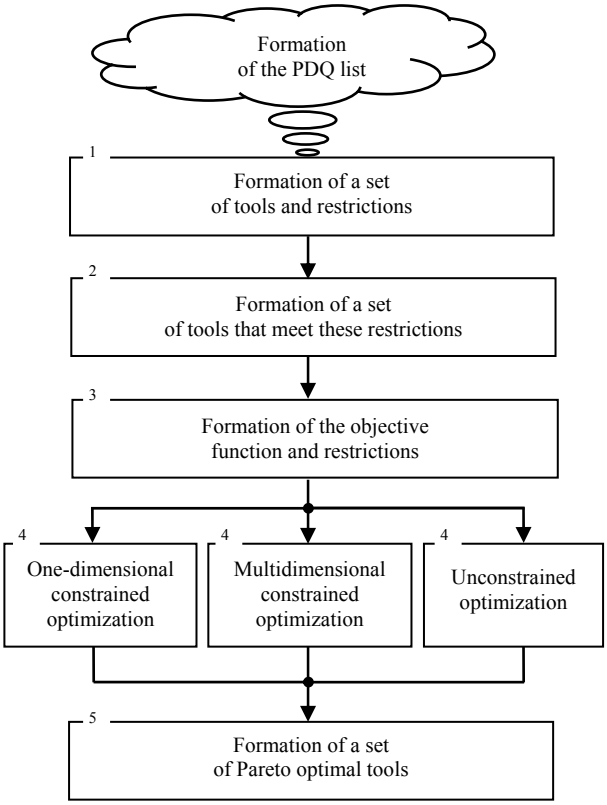

Fig. 1. Method of psychodiagnostic tool's determination for professional selection and training of specialists in complex ergatic systems

1. Formation of a set of psychodiagnostic tools that diagnose the feature X_i, that is the set $\{A_i\} = U^{-1}(X_i) \in T$. And also formation of a set of restrictions such as $P_i \geq P_{i_{given}}$ or $q_g \leq q_{g_{given}}$, $r_{i_1} \leq r_{i_2}$ etc.

2. Getting sets of psychodiagnostic tools $A_i^0 \subset A_i$ where these conditions are met. If $A_i^0 = \varnothing$, then it is necessary to return to clause 1 and adjust the restrictions.

3. Formation of the objective function and restrictions.

4.1. One-dimensional constrained optimization.

4.1.1.

$$P_i \to \max,$$
$$r_{i_1} \leq r_{i_1 given},$$
$$\ldots$$
$$r_{i_{k_i}} \leq r_{i_{k_i} given}.$$

4.1.2.

$$P_i \geq P_{i_{given}},$$
$$r_{i_j} \to \min,$$
$$\ldots$$
$$r_{i_k} \leq r_{i_{k given}}, k = 1,2,\ldots,k \neq j.$$

4.2. Multidimensional constrained optimization.

4.2.1.

$$P_i \to \max,$$
$$r_{i_j} \to \min, j = l_1, l_2, \ldots, l_m,$$
$$r_{i_k} \leq r_{i_{k given}}, k = 1,2,\ldots,k \neq l_1, l_2, \ldots, l_m.$$

4.2.2.

$$r_{i_j} \to \min, j = l_1, l_2, \ldots, l_m,$$
$$r_{i_k} \leq r_{i_{k given}}, k = 1,2,\ldots,k \neq l_1, l_2, \ldots, l_m,$$
$$P_i \geq P_{i_{given}}.$$

4.3. Unconstrained optimization.

4.3.1.

$$\min_t r_i(t) \text{ for every } i = 1,2,\ldots,k.$$

4.3.2.

$$\max_t P(t).$$

5. Setting a certain rule of priority and formation of a set A_i^1 of Pareto optimal [28] psychodiagnostic tools:

$$A_i^1 \subset A_i^0, \; A_i^L \neq \varnothing.$$

In the future it is possible to clarify the rule of priority or (in case of a small dimension of the A_i^1 set) confirm the tools according to some non-formalized rules.

Conclusions

The formalization of the structure of professional selection and training of specialists in complex ergatic systems helps to visualize and formulate requirements for the basic models and procedures used at various stages of professional selection. Formalized model of psychodiagnostic tools was obtained on the basis of developed algorithms of the main stages of professional selection. We also suggest a method for determining the set of psychodiagnostic tools according to the proposed specialist's standard and available resources of the professional selection process.

The present approach allowed formulating the task of choosing a set of diagnostic tools as an optimization problem. The developed set of algorithms helped to formalize selection stages for the optimal set of diagnostic tools solving the following tasks:

– choice of the best tool for a particular feature;

– construction of a number of tools for a set of features.

The developed algorithms can be interpreted as a complex method for defining a set of psychodiagnostic tools to test specialists in complex ergatic systems.

In future, it is necessary to develop methods for assessing the probability of correct diagnosis of psychological characteristics. It will help to plan an optimal strategy of professional selection taking into account different resource restriction.

Список літератури

1. Muchinsky P.M. Psychology applied to work: An introduction to industrial and organizational psychology / P.M. Muchinsky. – Boston: Cengage Learning, 2006. – 554 p.

2. Kaslow N.J. Competencies in professional psychology / N.J. Kaslow // American Psychologist. – 2004. – № 8(59). – P. 774-781.

3. Salvendy G. Handbook of human factors and ergonomics / G. Salvendy. – Hoboken: John Wiley & Sons, 2012. – 1752 p.

4. Arnold J. Work psychology: Understanding human behaviour in the workplace / J. Arnold. – London: Pearson Education, 2016. – 808 p.

5. Campbell J.S. Meta-analysis of personality assessments as predictors of military aviation training success / J.S. Campbell, M. Castaneda, S. Pulos // The International Journal of Aviation Psychology. – 2009. – № 1(20). – P. 92-109.

6. Hubbard T. Aviation Mental Health: Psychological Implications for Air Transportation / T. Hubbard, R. Bor. – London: Routledge, 2016. – 376 p.

7. Кузікова С.Б. Саморозвиток особистості, суб'єктний підхід / С.Б. Кузікова // Психологія особистості. – 2013. – № 1. – С. 77-86.

8. Кокун О.М. Психологія професійного становлення сучасного фахівця: монографія / О.М. Кокун. – К.: Інформ.-аналіт. агентство, 2012. – 200 с.

9. Батаршев А.В. Диагностика профессионально важных качеств / А.В. Батаршев и др.; под общ. ред. Г.А. Майорова. – Санкт-Петербург: Питер, 2007. – 250 р.

10. Сергієнко Н.П. Особливості професійної спрямованості особистості при виборі професії / Н.П. Сергієнко, М.Г. Щербак // Вісник Харківського національного педагогічного університету ім. Г.С. Сковороди. – 2012. – № 43(1). – С. 163-170.

11. Фролов Ю.В. Компетентностная модель как основа оценки качества подготовки специалистов / Ю.В. Фролов, Д.А. Махотин // Высшее образование сегодня. – 2004. – № 8. – С. 13-18.

12. Шило С.Г. Аналітична модель надійності оператора оперативно-диспетчерської служби МНС / С.Г. Шило, Г.В. Щербак, М.А. Павленко // Проблеми надзвичайних ситуацій. – 2009. – № 10. – С. 219-226.

13. Кісіль С.Г. Взаємозв'язок фізіологічного і психологічного в системному формуванні функціональних станів операторів / С.Г. Кісіль, І.О. Філенко // Вісник Харківського національного університету ім. В.Н. Каразіна. –2003. – № 599. – С. 145-151.

14. Кальниш В.В., Ена А.М. Современное состояние профессионального психофизиологического отбора в Украине / В.В. Кальниш, А.М. Ена // Медицина труда и промышленная экология. – 2006. – № 3. – С. 12-17.

15. Taylor S.E. Health psychology / S.E. Taylor. – New York: McGraw-Hill Education, 2015. – 430 p.

16. Богачев И.И. Модели деятельности человека в эргатических системах / И.И. Богачев. – М.: МАИ, 1987. – 184 с.

17. Павленко М.А. Методы и процедуры отбора операторов АСУ при использовании интеллектуальных систем поддержки принятия решений / М.А. Павленко // Збірник наукових праць Харківського національного університету Повітряних Сил. – 2012. – № 4(33). – С. 171-177.

18. Назаренко Н.А. Процедура выбора диагностических методик для диагностики претендентов в соответствии с построенным психологическим портретом и имеющимися ресурсами / Н.А. Назаренко // Сб. ст. международной научно-практической конференции "Інтеграционная стратегия становления профессионала в условиях многоуровневого образования". – Котлас, 22-24 июня 2007 г. – Ч. 1. – С. 469-473.

19. Brown T.A. Confirmatory factor analysis for applied research / T.A. Brown. – New York: Guilford Press, 2015. – 462 p.

20. Клімчук В.О. Факторний аналіз: використання у психологічних дослідженнях / В.О. Клімчук // Практична психологія та соціальна робота. – 2006. – № 8. – С. 43-48.

21. The Cambridge handbook of expertise and expert performance / K.A. Ericsson, N. Charness, P.J. Feltovich, R.R. Hoffman. – New York: Cambridge University Press, 2018. – 918 p.

22. Wickens C.D. Engineering psychology and human performance / C.D. Wickens. – New York: Psychology Press, 2015. – 544 p.

23. Kim J.O. Factor analysis: Statistical methods and practical issues / J.O. Kim, C.W. Mueller. – Newbury Park: SAGE, 1978. – 88 с.

24. Carter M.W. Operations research: a practical introduction / M.W. Carter, C.C. Price. – Boca Raton: CRC Press, 2017. – 416 p.

25. Fletcher R. Practical methods of optimization / R. Fletcher. – New York: John Wiley & Sons, 2017. – 456 p.

26. Wallenius J. Multiple criteria decision making, multiattribute utility theory: Recent accomplishments and what lies ahead / J. Wallenius // Management Science. – 2008. – № 7(54). – P. 1336-1349.

27. Podinovski V.V. The quantitative importance of criteria for MCDA / V.V. Podinovski // Journal of Multi-Criteria Decision Analysis. – 2002. – № 1(11). – С. 1-15.

28. Jiménez M. Pareto-optimal solutions in fuzzy multi-objective linear programming / M. Jiménez, A. Bilbao // Fuzzy sets and systems. – 2009. – № 18(160). – С. 2714-2721.

References

1. Muchinsky, P.M. (2006), *Psychology applied to work: An introduction to industrial and organizational psychology*, Cengage Learning, Boston, 554 p.

2. Kaslow, N.J. (2004), Competencies in professional psychology, *American Psychologist*, No. 8(59), pp. 774-781.

3. Salvendy, G. (2012), *Handbook of human factors and ergonomics*, John Wiley & Sons, Hoboken, 1752 p.

4. Arnold, J. (2016), *Work psychology: Understanding human behaviour in the workplace*, Pearson Education, London, 808 p.

5. Campbell, J.S., Castaneda, M. and Pulos, S. (2009), Meta-analysis of personality assessments as predictors of military aviation training success, *The International Journal of Aviation Psychology*, No. 1(20), pp. 92-109.

6. Hubbard, T. and Bor, R. (2016), *Aviation Mental Health: Psychological Implications for Air Transportation*, Routledge, London, 376 p.

7. Kuzikova, S.B. (2013), "Samorozvitok osobistosti: sub'ektnij pidhid" [Self-development of imagination, subjective approach], *Psychology of Personality*, No. 1. P. 77-86.

8. Kokun, O.M. (2012), "*Psihologiya profesijnogo stanovlennya suchasnogo fahivcya*" [*Psychology of professional formation of a modern specialist*], Inform.-analit. agentstvo, Kyiv, 200 p.

9. Batarshev, A.V. (2007), "*Diagnostika professional'no vazhnyh kachestv*" [*Diagnosis of professionally important qualities*], Piter, Sankt-Peterburg, 250 p.

10. Sergienko, N.P. and Shcherbak, M.G. (2012), "Osoblivosti profesijnoy spryamovanosti osobistosti pri vibori profesiyi" [Features of the professional orientation of the individual when choosing a profession], *Bulletin of Kharkiv National Pedagogical University named after G.S. Skovoroda*, No. 43(1), pp. 163-170.

11. Frolov, Y.V. and Mahotin, D.A. (2004), "Kompetentnostnaya model' kak osnova ocenki kachestva podgotovki specialistov" [The competence model as a basis for evaluating the quality of specialist training], *Higher Education Today*, No. 8, pp. 13-18.

12. Shilo, S.G., Shcherbak, G.V. and Pavlenko, M.A. (2009), "Analitichna model' nadijnosti operatora operativno-dispetchers'koï sluzhbi MNS" [Analytical model of reliability of the operator of the operational and dispatching service of the Ministry of Emergencies], *Emergency Problems*, No. 10, pp. 219-226.

13. Kisil', S.G. and Filenko, I.O. (2003), "Vzayemozv'yazok fiziologichnogo i psihologichnogo v sistemnomu formuvanni funkcional'nih staniv operatoriv" [Relationship of physiological and psychological in systematic formation of functional states of operators], *Bulletin of Kharkiv National University of V.N. Karazin*, No. 599. pp. 145-151.

14. Kal'nish, V.V. and Ena, A.M. (2006), "Sovremennoe sostoyanie professional'nogo psihofiziologicheskogo otbora v Ukraine" [The current state of professional psychophysiological selection in Ukraine], *Occupational Health and Industrial Ecology*, No. 3, pp. 12-17.

15. Taylor, S.E. (2015), *Health psychology*, McGraw-Hill Education, New York, 430 p.

16. Bogachev, I.I. (1987), "*Modeli deyatel'nosti cheloveka v ergaticheskih sistemah*" [*Models of human activity in ergatic systems*], MAI, Moscow, 184 p.

17. Pavlenko, M.A. (2012), "Metody i procedury otbora operatorov ASU pri ispol'zovanii intellektual'nyh sistem podderzhki prinyatiya reshenij" [Methods and procedures for the selection of ACS operators when using intelligent decision support systems], *Scientific Works of Kharkiv National Air Force University*, No. 4(33), pp. 171-177.

18. Nazarenko, N.A. (2007), "Procedura vybora diagnosticheskih metodik dlya diagnostiki pretendentov v sootvetstvii s postroennym psihologicheskim portretom i imeyushchimisya resursami" [The procedure for selecting diagnostic methods for diagnosing applicants in accordance with the constructed psychological portrait and available resources], *Collection of Scientific Works of the International Scientific-Practical Conference* "*Integration strategy of becoming a professional in the conditions of multilevel education*", 22-24 June, Kotlas, Russia, pp. 469-473.

19. Brown, T.A. (2015), *Confirmatory factor analysis for applied research*, Guilford Press, New York, 462 p.

20. Klimchuk, V.O. (2006), "Faktornij analiz: vikoristannya u psihologichnih doslidzhennyah" [Factor analysis: use in psychological research], *Practical Psychology and Social Work*, No. 8, pp. 43-48.

21. Ericsson, K.A., Charness, N., Feltovich, P.J. and Hoffman, R.R. (2018), *The Cambridge handbook of expertise and expert performance*, Cambridge University Press, New York, 918 p.

22. Wickens, C.D. (2015), *Engineering psychology and human performance*, Psychology Press, New York, 544 p.

23. Kim, J.O. and Mueller, C.W. (1978), *Factor analysis: Statistical methods and practical issues*, SAGE, +Newbury Park, 88 p.

24. Carter, M.W. and Price, C.C. (2017), *Operations research: a practical introduction*., CRC Press, Boca Raton, 416 p.

25. Fletcher, R. (2017), *Practical methods of optimization*, John Wiley & Sons, New York, 456 p.

26. Wallenius, J. (2008), Multiple criteria decision making, multiattribute utility theory: Recent accomplishments and what lies ahead, *Management Science*, No. 7(54), pp. 1336-1349.

27. Podinovski, V.V. (2002), The quantitative importance of criteria for MCDA, *Journal of Multi-Criteria Decision Analysis*. No. 1(11), pp. 1-15.

28. Jiménez, M. and Bilbao, A. (2009), Pareto-optimal solutions in fuzzy multi-objective linear programming, *Fuzzy Sets and Systems*, No. 18(160), pp. 2714-2721.

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МЕТОД ВИЗНАЧЕННЯ ПСИХОДІАГНОСТИЧНИХ МЕТОДИК ДЛЯ ПРОФЕСІЙНОГО ВІДБОРУ І ПІДГОТОВКИ ФАХІВЦІВ СКЛАДНИХ ЕРГАТИЧНИХ СИСТЕМ

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У роботі наводяться результати наукових досліджень в галузі інженерної психології відносно створення методу відбору комплекту психодіагностичних методик для завдань професійного відбору і підготовки фахівців складних ергатичних систем. На сучасному етапі процес профвідбору фахівців складних ергатичних систем стандартизовано, але окремі його складові наразі залишаються неформалізованими або мають суб'єктивний характер. Особливо це стосується етапів побудови еталону спеціаліста і формування оптимального комплекту психодіагностичних методик. Крім того, до істотних проблем щодо професійного відбору фахівців відносяться наступні: більшість застосовуваних методів побудови еталону спеціальності характеризуються значним суб'єктивізмом і безпосередньо залежать від кваліфікації експерта, що проводить відбір; жодна з існуючих моделей фахівця не є універсальною та в абсолютній більшості випадків має вузькопрофільний характер; відсутність формалізованих моделей психодіагностичних методик не дозволяє оптимальним чином вибрати ті, що необхідні для діагностики претендентів з урахуванням наявних обмежень і ресурсів; при оцінці узгодженості думок експертів не враховується ступінь їх компетентності, що на практиці може призводити до спотворення результатів. Розв'язання вказаних проблем надасть змогу розробити систему автоматизованої підтримки побудови еталону спеціальності фахівця і визначити необхідні для його профвідбору специфічні психодіагностичні методики. Для цього необхідно провести аналіз структури професійного відбору, розробити моделі психодіагностичної методики і побудови комплекту психодіагностичних методик, а також метод його визначення відповідно до побудованих еталонів та наявних ресурсів. Розроблений в роботі метод відбору комплекту психодіагностичних методик для завдань професійного відбору і підготовки фахівців складних ергатичних систем може бути використаний при автоматизації процесу профвідбору працівників-професіоналів будь-якої спеціалізації. Новизна запропонованого підходу полягає в формалізації процедури відбору комплекту діагностичних методик як завдання оптимізації. Розроблений комплекс алгоритмів дозволив формалізувати етапи вибору оптимального комплекту методик діагностики з метою вирішення завдань вибору найкращої методики для конкретної властивості та побудови низки методик для набору властивостей.

***Ключові слова**: складні ергатичні системи, фахівець, метод профвідбору фахівців, математичні моделі, інженерна психологія.*

МЕТОД ВЫБОРА ПСИХОДИАГНОСТИЧЕСКИХ МЕТОДИК ДЛЯ ПРОФЕССИОНАЛЬНОГО ОТБОРА И ПОДГОТОВКИ СПЕЦИАЛИСТОВ СЛОЖНЫХ ЭРГАТИЧЕСКИХ СИСТЕМ

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В работе приводятся результаты научных исследований в области инженерной психологии относительно создания метода отбора комплекта психодиагностических методик для задач профессионального отбора и подготовки специалистов сложных эргатических систем. На современном этапе процесс профотбора специалистов сложных эргатических систем стандартизировано, но отдельные его составляющие пока остаются неформализованными или носят субъективный характер. Особенно это касается этапов построения эталона специалиста и формирования оптимального комплекта психодиагностических методик. Существенные проблемы профессионального отбора специалистов следующие. Большинство применяемых методов построения эталона специальности характеризуются значительным субъективизмом и напрямую зависят от квалификации эксперта, который проводит отбор. Ни одна из существующих моделей специалиста не является универсальной и в абсолютном большинстве случаев имеет узкопрофильный характер. Отсутствие формализованных моделей психодиагностических методик не позволяет оптимальным образом выбрать те, которые необходимы для диагностики претендентов с учетом имеющихся ограничений и ресурсов. При оценке согласованности мнений экспертов не учитывается степень их компетентности, что на практике может приводить к искажению результатов. Решение указанных проблем позволит разработать систему автоматизированной поддержки построения эталона специальности специалиста и определить нужные для его профотбора специфические психодиагностические методики. Для этого необходимо провести анализ структуры профессионального отбора, разработать модели психодиагностической методики и построения комплекта психодиагностических методик, а также метод его определения относительно к построенным эталонам и имеющимся ресурсам. Разработанный в работе метод отбора комплекта психодиагностических методик для задач профессионального отбора и подготовки специалистов сложных эргатических систем может быть использован при автоматизации процесса профотбора работников-профессионалов любой специализации. Новизна предложенного подхода заключается в формализации процедуры отбора комплекта диагностических методик как задачи оптимизации. Разработаный комплекс алгоритмов позволил формализовать этапы выбора оптимального комплекта методик диагностики с целью решения задач выбора лучшей методики для конкретного свойства и построения ряда методик для набора свойств.

Ключевые слова: *сложные эргатические системы, специалист, метод профотбора специалистов, математические модели, инженерная психология.*