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APPLICATIONS OF FUZZY DECISION MAKING FOR EVALUATION OF STAFF TRAINING RESULTS

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***Abstract* — An approach to evaluation of the quality of staff training based on the use of fuzzy logic is proposed. The features of the requirements that are applied to the professional qualities of the first-line managers and the middle managers are considered. Contemplation of this task as a fuzzy optimization task made it possible to formulate a comprehensive criterion for measuring not only hard, but also soft skills.**

***Key Terms* — Fuzzy sets, hard skills, human capital, multi-criteria decision making, soft skills, uncertainty.**

The innovation sector plays a leading role in the economy of post-industrial society. Ensuring its effectiveness is impossible without the productive work of all the staff of the industrial enterprise, from the worker to the top manager. It is human capital as a result of its capitalization that becomes one of the main production resources. And this is a main distinction of the knowledge economy. It follows that the development of professional knowledge and skills of staff is the main way to ensure the competitiveness of the enterprise.

One of the most difficult questions that arises when providing a sufficient quality of vocational training staff, there is a direct and reasonable assessment of the achieved level of quality of professional development. It is the objective and justified assessment of the professional level that determines both the degree of motivation of employees to activate further training and development procedures in their chosen field of activity, and the ability of the top manager to create appropriate conditions for professional training of staff.

The purpose of this work is to determine the procedure for integrated evaluation of the quality of professional development of line managers and mid-level managers of an industrial enterprise, taking into account both the hard and soft skills that were formed through their training.

The problem of assessing the human capital of an enterprise is constantly in the center of attention of both scientists and practitioners. In the works of scientists such as O.A. Grishnova, D.L. Kirkpatrik, A.I. Dobrynin, S.A. Dyatlov, J.J. Philips, T.W. Schultz, S.V. Shekshnia and others, the increase in the value of human capital is considered in terms of the return on investment (ROI) in training. In general, ROI is a ratio that shows the profitability of a particular investment, in other words, this is the payback ratio. J.J. Philips emphasized that ROI is a macro-indicator, although data are collected at various micro levels to calculate it. So, in the paper [10] he describes in detail the methodology for using ROI in connection with the study of the impact of personnel training on business efficiency. However, it should be noted that the use of this indicator has two features. Firstly, it is advisable to use it after a long period after the training is completed. Secondly, this indicator to a greater extent directly reflects the hard skills of an individual employee or even the whole link and weakly reflects soft skills. Let's take a closer look at these two features.

The training process of any specialist usually consists of two parts. The first part is the training itself, during which professional knowledge is formed. The second part is post-training support, the task of which is to capitalize this knowledge, i.e. create conditions for the application of acquired knowledge and skills directly in professional activities.

Therefore, we need in an indicator of the efficiency that can be applied on-line. This makes it possible to adjust the learning process. In addition, the specifics of training managers are that they must improve their soft skills. Soft skills can be classified as a personality trait. Some of the most sought-after soft skills include: leadership, teambuilding, creativity, problem-solving, decision-making and others. That's why the training of managers involves the formation of not only hard, but also soft skills. D.L. Kirkpatrik [7] suggested evaluating the effectiveness of training in terms of the return on expectation (ROE). In accordance with this model, the development stage of the training program is carried out in close cooperation with the customer, which allows creating the desired behavior model.

In order to take these requirements into account, this paper is proposed to apply a comprehensive performance indicator, which is constructed with using the principles of fuzzy logic and combines both the elements of POE and the elements of POI.

Currently, fuzzy modeling is one of the most active and promising areas of applied research in the field of management and its quality assessment [1 – 6]. Suppose that when the training program was developing, professional qualities $X = (x_1, x_2, ..., x_n)$ (hard skills and soft skills) were identified that need to be formed in the training process. If these skills are considered additive [3, p. 298], a comprehensive indicator Z of the training efficiency can be constructed as the sum of private indicators, in which each term is attributed a specific gravity that reflects the importance of this indicator in the professional activity of a manager. Assignment of specific gravities $W = (w_1, w_2, ..., w_n)$ is carried out by the decision-maker, an expert or a group of experts in accordance with the hierarchy analysis method, taking into account the normalization conditions.

$$Z = \sum_{i=1}^{n} w_i \cdot F_i(x) \qquad (1)$$

where $F_i(x)$ is a private indicator.

In the process of forming a comprehensive indicator, a problem of developing a mechanism for converting the parameters of the measurement object (knowledges, skills and experiences) into indicators of its quality takes place. Let's consider the set X, which is a set of skills that need to be formed in the training process. Some element x reflects the skill that was formed as a result of the training and which is subject to evaluation. It is necessary to determine a degree of membership of these skills to the set X. Fuzzy logic suggests using for this purpose the function $\mu_{\widetilde{A}}(x)$ which can take a real number in the interval [0; 1]. The nearer the value of $\mu_{\widetilde{A}}(x)$ is to unity, the higher the grade of membership of x in $\widetilde{A}$. Thus, when assessing the quality of training, we would consider a fuzzy set $\widetilde{A}$. This set consists of pairs $(x, \mu_{\widetilde{A}}(x))$ where x is the requisite skill and $\mu_{\widetilde{A}}(x)$ is the membership function which returns a degree of membership x in the set $\widetilde{A}$:

$$\widetilde{A} = \left\{(x, \mu_{\widetilde{A}}(x)) \middle| x \in X\right\}. \qquad (2)$$

If the intersection of the fuzzy sets $\widetilde{A}$ and $\widetilde{B}$ is nonempty (the skills x_i and x_j must be present simultaneously), then the membership function is determined by the relation:

$$\mu_{\widetilde{A}\cap\widetilde{B}}(x) = \min\left\{\mu_{\widetilde{A}}(x), \mu_{\widetilde{B}}(x)\right\}, x \in X. \quad (3)$$

If the skills x_i and x_j are interchangeable, the membership function is determined as:

$$\mu_{\widetilde{A}\cup\widetilde{B}}(x) = \max\left\{\mu_{\widetilde{A}}(x), \mu_{\widetilde{B}}(x)\right\}, x \in X. \quad (4)$$

Attributing the value of the membership function for each x to be evaluated is carried out by an expert (or group of experts). For this purpose the verbal-numerical scale should be used. It is reasonable to apply the Harrington scale comparison (Table 1).

Table 1

Harrington desirability scale for evaluating the effectiveness of training

Numeric value	Modal rating
0.80–1.00	Very high
0.63–0.80	High
0.37–0.63	Average
0.20–0.37	Low
0.00–0.20	Extremely low

The choice of the Harrington scale is due to its widely using in the economy for validation of the complex index of enterprise effectiveness.

The scale [0; 1] is considered as the value of opportunities. The opportunity of an event is oriented towards a relative assessment of the truth of a given event, in contrast to its probability, which is calculated from the results of statistical studies [3 – 5].

For training linear managers and middle managers a comprehensive indicator Z consists of two different groups of private indicators. These groups differ in the principle of selecting measurement scales. To measure the private indicators that reflect hard skills (the first group), quantitative scales were used. During post training we measured the productivity of employees or groups of employees which were led by a manager. And these absolute values $y_i(x)$ $(i=\overline{1,k})$ of particular indicators were translated into their relative values $F_i(x)$. Reference [9] describes the principle of normalizing particular performance indicators. Based on the measurement results of the first group of private indicators, we obtain information similar to that which ROI gives.

To measure the private indicators that reflect soft skills (the second group), quality scale is applied. This is the ordinal scale, which uses linguistic variables for classification of characteristics. This type of scales is typically measures of non-numeric concepts like satisfaction with the result. In accordance with the objectives of training, it is necessary to determine soft skills that should be formed as a result of the training, and choose their desired value. In this case private indicator $F_i(x)$ $(i=\overline{k+1,n})$ characterizes the degree of achievement of this value. For linguistic approximation, the Harington function can also be used. Based on the measurement results of the second group of private indicators, we obtain information similar to that which ROE gives. If you have a group of experts, you can use the fuzzy technique for order of preference by similarity to ideal solution [8]. This method assumes that when constructing a complex indicator, the distance for each particular indicator from the ideal is estimated.

For interpretation of the obtained values of the comprehensive indicator of training efficiency which takes into account not only hard but also soft skills it is convenient to use the Harrington scale also.

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