A Fuzzy Comprehensive Evaluation System for Performance Appraisal Based on Clustering Algorithm

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Abstract. In response to the traditional performance evaluation methods that require a large amount of manpower and material resources to be uniformly allocated, and the storage methods of input data are not unified, resulting in low evaluation efficiency and accuracy, a performance evaluation fuzzy comprehensive evaluation system design method based on K-means clustering algorithm is proposed. The system consists of a data preparation module, a performance evaluation fuzzy evaluation module, a report processing module The system maintenance module constitutes the overall structure of the performance evaluation fuzzy comprehensive evaluation system. Using the Analytic Hierarchy Process to calculate the corresponding weights of performance evaluation indicators, a fuzzy evaluation model for performance evaluation is constructed. The K-means clustering algorithm is used to solve the fuzzy comprehensive evaluation model for performance evaluation, achieving the evaluation of performance evaluation and completing the design of the fuzzy comprehensive evaluation system for performance evaluation. The experimental results show that the evaluation efficiency and accuracy of this method are high.

Keywords: K-means clustering algorithm; Performance evaluation; Fuzzy evaluation; system design

1 Introduction

Improving management quality through performance evaluation is the starting point and destination of various types of work in schools. Whether it is school management work, moral education work, education and teaching research, faculty building, logistics, and general affairs work, the quality of work must be continuously improved through performance evaluation [1]. The performance evaluation process is an important way to conduct statistical analysis of factors such as work effectiveness and implementation, continuously optimize and improve. If performance appraisal cannot be evaluated, effective management cannot be carried out, and the effectiveness of performance appraisal cannot be discussed. The performance evaluation process can not only enable teachers to experience the problems in their own work, but also provide school management with control over the overall performance output of the

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school [2]. Therefore, how to establish a relatively complete, reasonable and fair comprehensive evaluation system to guide the distribution of Performance-related pay is a very important and urgent issue under the new situation.

At present, traditional evaluation systems only conduct simple statistics on the collected data to form performance evaluation results, and do not fully utilize the more valuable information hidden in the data to promote work improvement. Li et al. [3] used fuzzy comprehensive judgment to design a performance evaluation system, which resulted in significant errors in the evaluation results and low evaluation accuracy. It is difficult to explain which factors are related to work level, let alone how to effectively improve performance evaluation; Li et al. [4] proposed an evaluation system based on fuzzy comprehensive evaluation method, which uses mathematical tools to achieve fuzzy representation, inference, and discrimination during the evaluation process. Although various factors are considered comprehensively, there are problems with a long time and low evaluation accuracy.

To solve the problems in the above methods, this paper proposes a performance evaluation fuzzy evaluation system design method based on K-means clustering algorithm, which has relatively high evaluation efficiency and accuracy.

The design method of performance evaluation fuzzy evaluation system based on K-means clustering algorithm adopts visual programming language Del - phi 5 0 as a development tool and Windows 2008 as a system platform to build a performance evaluation fuzzy evaluation system. The main work of the data preparation stage includes the collection, extraction, and transformation of the original data [5]. Obtaining the original data is the main task of the data preparation module in the performance appraisal fuzzy comprehensive evaluation system. This method mainly collects the original data through manual keyboard input or automatic identification of answer cards, and realizes the integration of multiple files in the database [6]. Finally, convert the data into an input form suitable for the performance evaluation fuzzy comprehensive evaluation system, mainly including data smoothing, clustering, generalization, normalization, and attribute construction.

The fuzzy evaluation method is used to evaluate performance evaluation and obtain evaluation results. The first level fuzzy comprehensive evaluation process requires multiple iterations in the fuzzy comprehensive evaluation module [7]. The design method of the performance evaluation fuzzy comprehensive evaluation system based on K-means clustering algorithm is to design a subroutine to replace the first level fuzzy comprehensive evaluation process, which is convenient for the system to call multiple times. Produce a report based on the fuzzy comprehensive evaluation results of performance appraisal, including a summary of performance appraisal evaluations and ranking of performance appraisal scores by students and experts over the years [8]. The obtained report can be printed and queried. Set password protection function in the system. Generally, users only have browsing permission, and managers with passwords can maintain the performance evaluation fuzzy comprehensive evaluation system.

2 Construction of a Fuzzy Comprehensive Evaluation Model for Performance Appraisal

This article divides the evaluation factor set into two levels of evaluation criteria: the first level evaluation factor set and the second level evaluation factor set. The expression for the first level evaluation factor set U is as follows:

$$U = \{U_1, U_2, ..., U_3\} \tag{1}$$

Subdivide the first level evaluation factor set for fuzzy comprehensive evaluation of performance appraisal to determine the second level evaluation factor set:

$$\begin{cases} U_1 = \{u_{11}, u_{12}, ..., u_{1n}\} \\ U_2 = \{u_{21}, u_{22}, ..., u_{2n}\} \\ U_m = \{u_{m1}, u_{m2}, ..., u_{mn}\} \end{cases} \tag{2}$$

Determine the weight of fuzzy comprehensive evaluation factors for performance evaluation through Analytic Hierarchy Process. Divide various evaluation factors into two levels according to the principle of top-down, and classify evaluation indicators based on the attributes of evaluation objects according to different levels and systems. Compare various indicators in the same level and quantify the comparison results based on their corresponding importance. The set composed of each weight is called a weight set. For two levels of evaluation factors, first establish the corresponding weights of the first level evaluation factor set U, which is expressed as:

$$A = \{A_1, A_2, ..., A_m\} \tag{3}$$

Secondly, establish the corresponding weights for the secondary evaluation factor set U, and their expressions are as follows:

$$A = \begin{bmatrix} a_{11} & a_{12} & ... & a_{1n} \\ a_{21} & a_{22} & ... & a_{2n} \\ ... & ... & ... & ... \\ a_{m1} & a_{m2} & ... & a_{mn} \end{bmatrix} \tag{4}$$

Where A is constructs a weight vector matrix for the weight of performance evaluation fuzzy comprehensive evaluation indicators.

Based on the actual situation of fuzzy comprehensive evaluation of performance evaluation, the performance evaluation is divided into four levels (excellent, good, medium, poor), and a set of comments is established as follows:

$$V = \{v_1, v_2, v_3, v_4\} = \{excellent, good, medium, poor\} \tag{5}$$

In the fuzzy comprehensive evaluation of performance evaluation, the multi-level method is used to divide the evaluation factors into two categories, as shown in Figure 1. Then, starting from the lowest level, a preliminary fuzzy comprehensive evaluation is conducted, using the results as the evaluation matrix for the previous level, and then conducting the fuzzy comprehensive evaluation for the previous level until the highest level. This article uses consistency testing to determine the consistency of judgment matrices with higher orders.

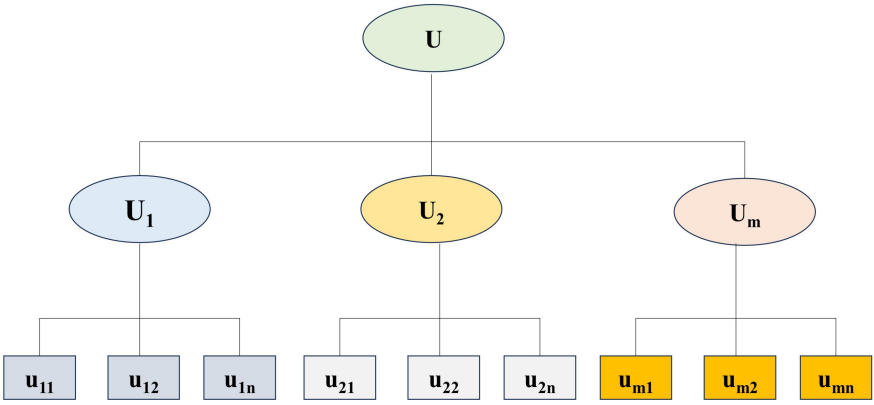

Fig. 1. Structure diagram of performance evaluation fuzzy comprehensive evaluation system.

Calculate the membership degree corresponding to the evaluation indicators in the evaluation factor set based on the collected evaluation data, and construct a fuzzy matrix U_{mn}:

$$U_{mn} = \begin{bmatrix} U_{11} & U_{12} & U_{13} & U_{14} & U_{15} \\ U_{21} & U_{22} & U_{23} & U_{24} & U_{25} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ U_{m1} & U_{m2} & U_{m3} & U_{m4} & U_{m5} \end{bmatrix} \tag{6}$$

Where U_{ij} is the degree of membership corresponding to the evaluation factor U_i for the evaluation set U_j.

Based on the calculated degree of membership, a fuzzy comprehensive evaluation model F for performance evaluation is constructed, and its expression is as follows:

$$F = \frac{wi \times U_{mn}}{U_j} \times \delta \tag{7}$$

Where δ is a fuzzy operator; w_i is the weight of the i-th indicator in the same subset.

3 Model solution

The basic principle of the K-means clustering algorithm is to divide a given dataset into K different classes and find the clustering center of each class, so as to minimize the non similarity features (such as distance) between each class.

Assuming $B(i) = \{i_1, i_2, ..., i_T\}, i = 1, 2, ..., N; \lambda^{i_1}, \lambda^{i_2}, ..., \lambda^{i_T}$ are uniformly distributed weight vector λ^i the nearest T weight vectors around i.

For swarm $X = \{x_1, x_2, ..., x_n\}$, x_i ($i=1,2,...,n$) represent d dimension data points $xi = (x_{i1}, x_{i2}, ..., x_{id})$. Normalizing it as $F(x_i) = \frac{1}{\lambda^{i_T} F} B(i)$.

Dividing population X and obtain three subpopulations I_A, I_B, and I_C, so that there are ξ_1 individual, ξ_2 individuals in I_B, ξ_3 individuals in I_C. At the initial stage, set ξ_1 ξ_2 and ξ_3 meet the following requirements:

$$\xi_1 = \xi_2 = \xi_3 = \frac{N}{3} \tag{8}$$

The design method of performance evaluation fuzzy comprehensive evaluation system based on K-means clustering algorithm, where the sum of squared distances from each data point in the class to the clustering center $c_j=(c_{j1}, c_{j2}, c_{j3})$ is calculated as follows:

$$J(C_j) = \sum_{x_i \in C_j} \| x_i - c_j \|^2 \tag{9}$$

Where $\|\bullet\|$ is Euclidean distance, C_j is varied clusters. The sum of squares of the total distances of K different classes is calculated as follows:

$$J(C) = \sum_{j=1}^{K} J(C_j) = \sum_{j=1}^{K} \sum_{x_i \in C_j} \| x_i - c_j \|^2 \tag{10}$$

The element u_{ij} of the membership matrix $U_{n \times K}$ is defined as follows:

$$u_{ij} = \begin{cases} 1, if \forall k \neq j, \| x_i - c_j \|^2 \leq \| x_i - c_k \|^2 \\ 0, otherwise \end{cases} \tag{11}$$

If the data point x_i is closest to the cluster center c_j, then xi belongs to the C_j class.

According to the properties of the membership matrix, each cluster center is continuously updated until the objective function $J(C)$ is less than a predetermined threshold, or the change in value relative to the previous objective function is less than a certain threshold. At this point, the obtained cluster center is considered the best cluster center, and the corresponding partition is the final partition of dataset X.

Meet the termination conditions, stop the algorithm, output the results of the performance evaluation fuzzy comprehensive evaluation model, and complete the fuzzy comprehensive evaluation of the performance evaluation.

4 Experiment

The design method of performance evaluation fuzzy comprehensive evaluation system based on K-means clustering algorithm and the design and implementation method of performance salary evaluation system based on fuzzy comprehensive evaluation (without K-means clustering algorithm) were respectively used for testing. The evaluation accuracy of the two methods in designing the system was compared, and the test results are shown in Figure 2. When designing a performance appraisal fuzzy comprehensive evaluation system based on K-means clustering algorithm, the accuracy of the system's implementation is higher than that of the design and implementation method based on fuzzy comprehensive evaluation performance wage evaluation system (without K-means clustering algorithm), regardless of the number of iterations being 1, 2, 3, 4, 5, and 6. When the number of iterations is 5, the accuracy of the algorithm implementation in this paper is 0 92, which is six percentage points higher than the design and implementation method of a performance salary evaluation system based on fuzzy comprehensive evaluation. When the number of iterations is 6, the accuracy of the algorithm implemented in this paper is 0 92 to 0 85, therefore the optimal number of iterations for the algorithm is 5.

In addition, the performance evaluation fuzzy comprehensive evaluation system design method based on K-means clustering algorithm and the design and implementation method based on fuzzy comprehensive evaluation performance salary evaluation system (without K-means clustering algorithm) were respectively used for testing. The evaluation time of the two methods for designing the system was compared, and the test results are shown in Table 1.

Table 1. Evaluation time of different methods.

Number of iterations	Our method	Design Method of Evidence Reasoning System
1	0.63	1.31
2	0.66	0.11
3	0.71	0.62
4	0.69	0.43
5	0.60	1.24
6	0.57	1.10

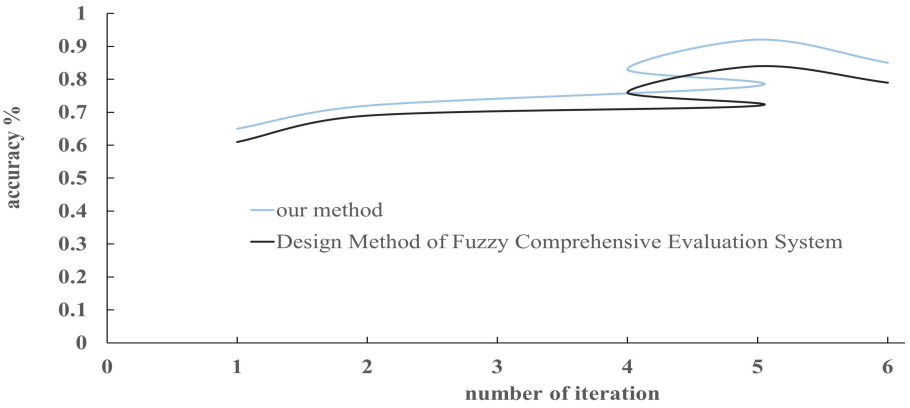

Fig. 2. Evaluation accuracy of different methods.

The system designed using the K-means clustering algorithm based fuzzy comprehensive evaluation system design method for performance evaluation takes less time than the evidential reasoning based performance evaluation system design method for evaluation, regardless of the number of iterations. Because the performance evaluation fuzzy comprehensive evaluation system design method based on K-means clustering algorithm has designed a subroutine in the fuzzy comprehensive evaluation module to replace the fuzzy comprehensive evaluation process, which facilitates multiple system calls, shortens the time used for system evaluation, and improves the evaluation efficiency of the performance evaluation fuzzy comprehensive evaluation system design method based on K-means clustering algorithm.

5 Conclusion

Performance evaluation is related to the development of schools and is based on evaluation techniques and theories to evaluate whether the performance evaluation meets the standards. The current design method of performance evaluation fuzzy comprehensive evaluation system has problems of low evaluation efficiency and accuracy. The proposed K-means clustering algorithm based performance evaluation fuzzy comprehensive evaluation system design method can accurately complete performance evaluation in a short time, laying the foundation for the development of performance evaluation system. The method proposed in this article has certain feasibility, as it can not only generate multiple evaluation indicators, but also provide corresponding values based on the actual situation of performance evaluation. And this multifaceted evaluation method is due to the K-means clustering algorithm used in this article, which analyzes different strategies to obtain more reasonable and fair performance evaluation results.

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