Research on the Evaluation Model of Teachers' Teaching Quality Based on Principal Component Analysis

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Abstract. Teaching quality evaluation is one of the important contents of teaching management. This paper can achieve a more scientific and reasonable evaluation of teaching quality by building a principal component comprehensive evaluation model. Therefore, this paper selects the actual evaluation data of eight teachers for analysis, calculates the correlation coefficient matrix of evaluation data and its eigenvalues and eigenvectors, and then calculates the information contribution rate and cumulative contribution rate of eigenvalues. In the use of principal component analysis, four principal components with large contribution rate are selected to calculate each principal component value, and a principal component comprehensive evaluation model is constructed. With this model, the comprehensive evaluation value of each teacher is calculated and sorted.

Keywords: Comprehensive evaluation model · principal components · correlation coefficient · Contribution rate · MATLAB

1 Background

The evaluation of teachers' teaching quality is an important work of school teaching management. Whether the evaluation is scientific or not is related to each teacher's growth and teaching enthusiasm, which is of great significance to the development of education. Therefore, teachers' teaching evaluation must be scientific and rigorous. In the actual evaluation work, there are the following situations: First, the evaluation index system is formulated by the school itself; Secondly, the calculation models are different, and most of them use weighted average ranking. The above evaluation system has two problems: one is whether the evaluation index and its weight have scientific basis; the other is whether the calculation model is scientific. If these two issues are not explained clearly, it is difficult to ensure the objective and fair evaluation results. For the first question, the author has studied the evaluation index and its weight with the analytic hierarchy process. The scientific method for formulating evaluation indicators has been given, and relevant papers have been written. This research has been established in the author's unit and has received financial support [1]. For the second question, the author wants to get the calculation model of evaluation data through principal component analysis. Solve the problem that the evaluation data is too centralized and the calculation model is too simple.

F. Huang et al. (Eds.): ICAIE 2023, AHCS 15, pp. 38–44, 2024.
https://doi.org/10.2991/978-94-6463-242-2_6

Table 1. Evaluation indicators and their weights

Indicator code	Index content		Indicator code	Index content
X1	Respect students and care about their growth		X6	Highlighted teaching content, focusing on combination with practice
X2	Be a teacher and influence students with good words and deeds		X7	Let students clearly understand the teaching objectives, assessment requirements and assessment methods of this course
X3	Abide by teaching discipline and strictly require students		X8	Standard teaching language, clear expression and explanation
X4	Inspiring, interactive and good classroom atmosphere		X9	Pay attention to communication between teachers and students after class
X5	The homework can help students consolidate their knowledge,		X10	Students' ability to analyze and solve practical problems has been greatly improved

2 Research Materials

This paper takes the evaluation index system and real data of teachers in real work as an example. Due to space limitation, only secondary indicators and their weights are used.

2.1 Evaluation Index System

The evaluation index system is the basis for teachers' teaching evaluation [2]. This paper has sorted out the evaluation indexes according to the real evaluation indexes in the work, and the evaluation indexes and weights are shown in Table 1.

2.2 Evaluation Data

For the above indicators, this paper provides real evaluation data, as shown in Table 2.

In Table 2, x1, x2, x3, x4, x5, x6, x7, x8, x9, x10Represents the 10 indicators of the evaluation, Limited to space, only eight teachers are evaluated only, s1, s2, s3, s4, s5, s6, s7, s8 On behalf of 8 teachers. It can be seen from Table 2 that the evaluation scores are high and the difference is not large, so it is difficult to distinguish the advantages and disadvantages of teachers' scores. In order to better distinguish the evaluation results of teachers, it is necessary to make the evaluation data become decentralized. Principal component analysis can solve this problem better. [3].

Table 2. Data sheet of teachers' teaching evaluation

Teachers	Evaluating indicator									
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
s1	99.52	99.76	99.39	99.39	99.76	99.88	99.88	99.76	99.76	99.39
s2	99.79	99.68	99.68	99.47	99.89	99.37	100	99.89	99.79	99.68
s3	99.89	99.68	99.79	99.58	99.58	99.68	99.79	99.58	99.89	100
s4	100	99.85	99.7	99.85	100	99.55	99.7	100	100	99.24
s5	99.58	99.17	99.5	98.83	94.08	99.5	99.5	99.67	99.17	94.75
s6	99.4	99.13	99.13	98.73	97.33	99.73	99.53	99.67	99.93	96.6
s7	99.86	100	100	99.71	99.86	99.86	99.71	99.86	99.86	99.42
s8	99.13	99.67	98.83	99.73	99.67	94.75	100	99.68	99.85	99.5

3 Research Methods

3.1 Data Processing

Design a matrix for the raw data of evaluation in Table 2, i.e. $A = [a_{i1}, a_{i2}, \cdots, a_{i10}]$, $i = 1, 2, \cdots, 8$.

Standardize the data of the matrix. Standardized processing $\tilde{a}_{ij} = \frac{a_{ij}-\mu_j}{s_j}$, $i = 1, 2, \cdots, 8; j = 1, 2, \cdots, 10$.

Formula: In the formula: $\mu_j = \frac{1}{8}\sum_{i=1}^{8} a_{ij}$, $s_j = \sqrt{\frac{1}{8-1}\sum_{i=1}^{8}(a_{ij}-\mu_j)^2}$, $j = 1, 2, \cdots, 10$. That is, μ_j, s_j are the sample mean and sample variance of the jth index [4].

3.2 Calculation of Correlation Coefficient Matrix of Evaluation Indexes

Matrix formula for calculating correlation coefficient of evaluation index:

$$r_{ij} = \frac{\sum_{k=1}^{8} \tilde{a}_{ki} \cdot \tilde{a}_{kj}}{8-1}, i = 1, 2, \cdots, 8; j = 1, 2, \cdots, 10.$$

In the formula: $r_{ij} = 1$, $r_{ij} = r_{ji}$, r_{ij} is the correlation coefficient between the ith index and the jth index. The correlation coefficient matrix is shown in Table 3.

3.3 Principal Component Analysis

3.3.1 Calculation of Eigenvalue and Eigenvector of Correlation Coefficient Matrix, Information Contribution Rate and Cumulative Contribution Rate of Each Eigenvalue

Use MATLAB software to perform principal component analysis on 10 indicators, calculate the eigenvalue and eigenvector of the correlation coefficient matrix in Table 4,

Table 3. Correlation coefficient matrix of evaluation indexes

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
X1	1.0000	0.4628	0.9353	0.3667	0.2581	0.6920	−0.1410	0.5212	0.1760	0.2827
X2	0.4628	1.0000	0.4838	0.9266	0.8443	−0.0411	0.5835	0.5595	0.5187	0.8590
X3	0.9353	0.4838	1.0000	0.3052	0.1895	0.7108	−0.1458	0.4170	0.0255	0.2399
X4	0.3667	0.9266	0.3052	1.0000	0.8275	−0.3001	0.6429	0.4868	0.5500	0.8605
X5	0.2581	0.8443	0.1895	0.8275	1.0000	−0.1482	0.7326	0.4288	0.8341	0.9727
X6	0.6920	−0.0411	0.7108	−0.3001	−0.1482	1.0000	−0.5051	0.2160	−0.0771	−0.1797
X7	−0.1410	0.5835	−0.1458	0.6429	0.7326	−0.5051	1.0000	0.1648	0.3665	0.7955
X8	0.5212	0.5595	0.4170	0.4868	0.4288	0.2160	0.1648	1.0000	0.3060	0.3138
X9	0.1760	0.5187	0.0255	0.5500	0.8341	−0.0771	0.3665	0.3060	1.0000	0.7301
X10	0.2827	0.8590	0.2399	0.8605	0.9727	−0.1797	0.7955	0.3138	0.7301	1.0000

Table 4. Principal component analysis results

Serial No	1	2	3	4	5	6	7	8	9	10
Information contribution rate of eigenvalue	52.188	28.4768	7.5896	6.4135	3.5039	1.4221	0.4062	0	0	0

and then calculate the information contribution rate and cumulative contribution rate of each eigenvalue from the eigenvalue [5]. The formula for calculating the information contribution rate is: $b_j = \frac{\lambda_j}{\sum_{k=1}^{10} \lambda_k}, j = 1, 2, \cdots, 10$; The calculation formula of cumulative contribution rate is $\alpha_p = \frac{\sum_{k=1}^{p} \lambda_k}{\sum_{k=1}^{10} \lambda_k}, p = 1, 2, \cdots, 10$. [6] The characteristic values and their information contribution rate and cumulative contribution rate are shown in Table 4.

The cumulative contribution rate of the first four characteristic values is shown in Fig. 1.

From the cumulative contribution rate, the contribution rate of the first four principal components reaches 94.6678%, so the first four principal components are taken for comprehensive evaluation.

3.3.2 Principal Component Calculation

Multiply the characteristic vectors corresponding to the characteristic roots of the first four principal components by the standardized index variables to obtain the calculation

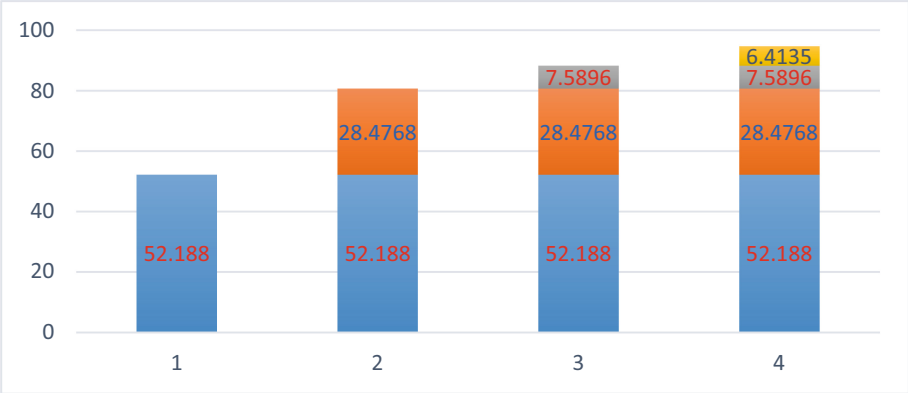

Fig. 1. The cumulative contribution rate of the first four eigenvalues

expressions of the four principal components as follows: [7]

$$
\begin{aligned}
y_1 &= 0.2012\tilde{x}_1 + 0.4119\tilde{x}_2 + 0.1745\tilde{x}_3 + 0.4042\tilde{x}_4 + 0.4175\tilde{x}_5 \\
&-0.0313\tilde{x}_6 + 0.2973\tilde{x}_7 + 0.2494\tilde{x}_8 + 0.3118\tilde{x}_9 + 0.4159\tilde{x}_{10}, \\
y_2 &= 0.5034\tilde{x}_1 + 0.0473\tilde{x}_2 + 0.5107\tilde{x}_3 - 0.0664\tilde{x}_4 - 0.1111\tilde{x}_5 \\
&+0.5348\tilde{x}_6 - 0.3267\tilde{x}_7 + 0.2257\tilde{x}_8 - 0.0976\tilde{x}_9 - 0.1170\tilde{x}_{10}, \\
y_3 &= -0.0260\tilde{x}_1 - 0.2265\tilde{x}_2 - 0.1530\tilde{x}_3 - 0.2712\tilde{x}_4 + 0.2458\tilde{x}_5 \\
&+0.3201\tilde{x}_6 - 0.2517\tilde{x}_7 - 0.2496\tilde{x}_8 + 0.7410\tilde{x}_9 + 0.1161\tilde{x}_{10}, \\
y_4 &= -0.1093\tilde{x}_1 - 0.0588\tilde{x}_2 - 0.3011\tilde{x}_3 - 0.0117\tilde{x}_4 - 0.0158\tilde{x}_5 \\
&-0.1171\tilde{x}_6 - 0.2193\tilde{x}_7 + 0.8466\tilde{x}_8 + 0.2188\tilde{x}_9 - 0.2591\tilde{x}_{10},
\end{aligned}
$$

It can be seen from the coefficient of principal component that the first principal component mainly reflects the information of indicators 2, 4, 5, 7, 9 and 10, mainly reflecting the interaction between teachers and students; The second principal component mainly reflects the information of the 1, 3 and 6 indicators, mainly reflecting teachers' attitude towards students; The third principal component mainly reflects the information of the 6 and 9 indicators, mainly reflecting that teachers are more practical in teaching; The fourth principal component mainly reflects the information of the 8 indicator, mainly reflecting the teachers' more expressive ability in teaching. Substitute the standardized data of 10 indicators into 4 principal component expressions to obtain 4 principal component values [8].

3.3.3 Construction of Principal Component Comprehensive Evaluation Model

With the four principal component contribution rates (four decimal places reserved) as the weight, the principal component comprehensive evaluation model is constructed:

$$Z = 0.5219y_1 + 0.2848y_2 + 0.0759y_3 + 0.0641y_4$$

Substitute the four principal components of each teacher into the above formula to get the comprehensive evaluation value of each teacher, as shown in Table 5.

Table 5. Comprehensive evaluation value and ranking of four principal components of teachers

Teachers	s1	s2	s3	s4	s5	s6	s7	s8
Comprehensive evaluation value	0.1952	0.7576	0.7355	1.3557	−2.0350	−1.4185	1.2972	−0.8877
Ranking	5	3	4	1	8	7	2	6

4 Conclusion

From the above results, we can see that the teacher evaluation data has been clearly differentiated. Therefore, this study effectively solved the second problem that the author began to put forward, namely, the problem that the evaluation data is too centralized and the calculation model is too simple [9].

The conclusion of this paper verifies that principal component analysis can be used to evaluate teaching results in teaching. In other areas of education, such as evaluating students' achievements and evaluating human resources, this evaluation method can be used for reference, which has played a guiding role in the future evaluation work [10].

Acknowledgments. This article is based on the Shandong Institute of Commerce and Technology "Uncover the list and take the lead" project, Item No.: A211, the project content is: the research and practice of the quality evaluation model construction of high-quality classroom. Thank the school for its financial support and encouragement, and thank colleagues and software technicians for their selfless help.

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