Evaluation Method of Online Teaching Quality in Colleges and Universities Based on Fuzzy Analytic Hierarchy Process

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Abstract. Classroom teaching quality evaluation is an important part of the overall teaching quality evaluation system in colleges and universities. The traditional multiple linear regression method of teaching quality evaluation lacks the calculation of evaluation index weight, which leads to low evaluation accuracy. In this regard, this paper proposes an online teaching quality evaluation method based on the fuzzy analytic hierarchy process. In this study, the evaluation index system is constructed, and the weight rationality of each layer of evaluation index is determined by using the judgment matrix. Then, the weight value of each index is calculated, and the evaluation results are calculated scientifically to reduce the evaluation error and realize the objective and accurate evaluation of online teaching quality in colleges and universities. In the experiment, this paper verifies the evaluation accuracy of the proposed evaluation method. The experimental analysis proves that the proposed evaluation method has high evaluation accuracy in the evaluation of online teaching quality in colleges and universities.

Keywords: Fuzzy analytic hierarchy process · Online teaching quality evaluation method in colleges and universities · Judgment matrix

1 Introduction

Analytic Hierarchy Process (AHP) is proposed by professor T. L. Saaty in the 1970s. It is a system analysis method combining qualitative analysis and quantitative analysis. The key step of the method is to construct the judgment matrix. Sometimes, due to the diversity of the decision-maker's understanding of things and the complexity of objective things, different decision-makers have different preferences for the decision-making objects. The judgment matrix given can not reflect the reality well, so there is "uncertainty" [1]. Its basic principle is to regard the complex problem to be studied as a large system, through the analysis of multiple factors of the system, to draw an orderly level of interconnection among the factors. Then, experts are invited to judge each factor of each level objectively, and the quantitative expression of the relative importance is given correspondingly. Then, a mathematical model is established to calculate the weight of the relative importance of all factors of each level and rank them, and finally, planning decisions are made

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according to the ranking results [2]. The purpose of classroom teaching quality evaluation is to promote the improvement of teaching quality. The establishment of classroom teaching quality evaluation index system must follow this purpose. If we want to apply the analytic hierarchy process, first of all, we should select the most important key evaluation index from many complex factors, and form a multi-level index system according to the restrictive relationship between them.

The quality of the index system construction is the premise of successful evaluation, and the number of index system levels depends on the complexity of the problem and the accuracy requirements of the evaluation. Fuzzy mathematics is a mathematical tool created by Zadeh in the 1960s to study and deal with fuzzy phenomena. The Fuzzy Analytic Hierarchy Process (FAHP) is obtained by extending AHP to fuzzy environment. The fuzzy analytic hierarchy process (FAHP) uses the interval [0,1] to qualitatively describe the objective "uncertainty". Based on the fuzzy consistent relation and fuzzy consistent matrix of the fuzzy set theory, a more satisfactory optimization result can be obtained in the evaluation of the scheme optimization with multi-index and fuzziness. This method is applied to the evaluation of teaching quality.

The evaluation of the online teaching quality in colleges and universities was first carried out by collecting artificial evaluation [3]. However, the evaluation results obtained by this method are blind and absolute to some extent, and there are shortcomings in objectivity and scientificity, which can not reflect the real level of online teaching quality in Colleges and universities. However, the current teaching quality evaluation method combined with the new theory mainly evaluates the teaching quality through a single index, which has the problem of low efficiency. The evaluation results are one-sided, so it can not comprehensively evaluate the teaching effect of teachers [4]. Therefore, in order to make a scientific and considerable evaluation of the quality of online teaching in colleges and universities, it is necessary to develop a new evaluation method. Through the fuzzy analytic hierarchy process, it is to quantify and calculate the evaluation index so as to obtain a more objective evaluation results. It is also to evaluate the quality of teaching. When designing the evaluation method, we should fully consider the objective attributes of the evaluation index, avoid the traditional evaluation method of weighted sum of various indexes, and fundamentally improve the objectivity of teaching quality evaluation. It is helpful for teachers to establish a clear understanding of their own teaching quality to improve teaching methods and promote the reform of online teaching in Colleges and universities [5].

2 Research on the Evaluation Method of Online Teaching Quality in Colleges and Universities Based on Fuzzy Analytic Hierarchy Process

2.1 Construction of Evaluation Index System Based on the Fuzzy Analytic Hierarchy Process

To evaluate the teaching quality of colleges and universities, we must first construct a unified evaluation index system and confirm the evaluation criteria [6]. In this regard, the fuzzy analytic hierarchy process is used to construct the specific index system, which

is mainly divided into three levels, namely, the target level, the criterion level and the scheme level. The specific construction steps are as follows.

First of all, students' evaluation of teachers' teaching quality is set as the overall goal of this evaluation, that is, target level A. Among them, the next layer of A includes four criteria, namely, teaching attitude, teaching method, teaching content and teaching effect. The specific expression is as follows:

$$A = \{B_1, B_2, B_3, B_4\} \tag{1}$$

$$B_1 = \{C_1, C_2, C_3\} \tag{2}$$

$$B_2 = \{C_4, C_5, C_6, C_7\} \tag{3}$$

$$B_3 = \{C_8, C_9, C_{10}, C_{11}, C_{12}\} \tag{4}$$

$$B_4 = \{C_{13}, C_{14}, C_{15}, C_{16}, C_{17}, C_{18}\} \tag{5}$$

where B_1, B_2, B_3 and B_4 respectively represent the four evaluation criteria mentioned above; C_1-C_{18} respectively represent different evaluation indicators, and the hierarchical structure constructed is shown in the Table 1.

According to the evaluation index hierarchy constructed above, the weight of each layer can be determined.

2.2 Determination of Evaluation Weight

The fuzzy analytic hierarchy process is used to scientifically quantify the weight of each index to eliminate the more subjective evaluation components, and the constructed judgment matrix is used to determine the rationality of the weight of each layer to improve the objectivity of the evaluation results [7].

The judgment function is set as $f(x, y)$, which is used to represent the importance between x and y for the whole f [8]. To quantify the importance, the expression is as follows.

$$f(x, y) = \frac{1}{f(y, x)} \tag{6}$$

According to the proportion scale of the fuzzy analytic hierarchy process, the judgment table of importance is constructed, and the specific judgment criteria are shown in the Table 2.

Assume that $X = \{x_1, x_2, ...x_n\}$, according to the above judgment basis of importance, each factor is compared to construct the judgment matrix C, and the specific expression is as follows:

$$C = \begin{bmatrix} C_{11} & C_{12} & \ldots & C_{1n} \\ C_{21} & C_{22} & \ldots & C_{2n} \\ \ldots & \ldots & \ldots & \ldots \\ C_{m1} & C_{m2} & \ldots & c_{mn} \end{bmatrix} \tag{7}$$

Table 1. Hierarchical structure of evaluation indicators

Target layer	Criterion layer	Scheme layer
Comprehensive Evaluation of Online Teaching Quality in Colleges and Universities A	Teaching attitude B_1	Quality of teaching plan C_1
		Preparation of teaching AIDS C_2
		Teaching core C_3
	Teaching methods B_2	Teaching form C_4
		Teacher-student interaction C_5
		Teaching organization C_6
		Teaching methods C_7
	Teaching content B_3	Organization of teaching materials C_8
		Teaching focus C_9
		Collaborative teaching C_{10}
		Teaching thinking C_{11}
		Teaching philosophy C_{12}
	Teaching effect B_4	Knowledge and ability C_{13}
		Emotional cultivation C_{14}
		Values C_{15}
		Face the whole C_{16}
		Teach students in accordance with their aptitude C_{17}
		Popularization of teaching C_{18}

Table 2. Judgment table of importance degree of the fuzzy analytic hierarchy process

Degree of importance	$f(x, y)$	$f(y, x)$
X is "as important as y"	1	1
X is "slightly more important" than y	3	1/3
X is "significantly more important" than y	5	1/5
X is "very important" than y	7	1/7
X is "absolutely more important" than y	9	1/9
The importance of X over y is between the levels.	2, 4, 6, 8	1/2, 1/4, 1/6, 1/8

$$C = (C_{ab})_{m \times n} \tag{8}$$

$$C_{ab} = f(x_a, x_b) \tag{9}$$

According to the above judgment matrix, the maximum eigenvalue can be solved to obtain the corresponding eigenvector, and the specific expression is as follows:

$$\delta = (x_1, x_2, ...x_n) \tag{10}$$

where, δ represents the eigenvector corresponding to the largest eigenvalue, and the value is normalized to obtain the weight of the evaluation index of the scheme layer. The specific expression is as follows.

$$C_i = (i_1, i_2, i_n) \tag{11}$$

where, C_i represents the weight corresponding to the evaluation index of scheme layer C, and i_n represents the weight value [9]. In order to test the consistency of the judgment index, it can be tested by the consistency index and the average consistency index of the same level. The specific formula is as follows:

$$R = \frac{I}{T} \tag{12}$$

where, R represents the random consistency ratio of the judgment matrix, I represents the consistency index of the judgment matrix, and T represents the average consistency index of the same level. When the R value is less than 10%, it means that the weight distribution of the judgment matrix constructed at this moment is reasonable. Similarly, if the R value exceeds 10%, it means that the judgment matrix needs to be adjusted. The constructed matrix is tested according to the above test method [10]. If the test result is not up to standard, it needs to be optimized until the test standard is up to standard. For the consistency index of the judgment matrix, there is a corresponding solution, and the specific solution expression is as follows:

$$I = \frac{\gamma_{\max} - n}{n + 1} \tag{13}$$

where $\gamma_{\max}$ represents the largest eigenvalue and n represents the number of indices.

After the evaluation weight is determined, the teaching quality can be evaluated, and the specific expression is as follows:

$$F = C \cdot X^T \tag{14}$$

where F represents the teaching quality evaluation score, C represents the matrix judgment value, and X represents the importance value of the index.

The determination of the evaluation weight can be realized according to the above steps, and the final evaluation score is obtained. This part of the content and the above evaluation index system are set together [11]. So far, the design of the online teaching quality evaluation method based on the fuzzy analysis level is completed.

3 The Experimental

In order to better illustrate that the proposed online teaching quality evaluation method based on fuzzy analysis hierarchy is superior to the traditional teaching quality evaluation method in the evaluation accuracy, after the theoretical design is completed, the experimental link is constructed, and the actual evaluation effect of the evaluation method is analyzed.

Table 3. Specific parameters of teaching quality judgment matrix

A	B_1	B_2	B_3	B_4	γ_{max}	R
B_1	1	1	3	4	4.02564	0.03596
B_2	1	1	3	4		
B_3	1/3	1/3	1	2		
B_4	1/4	1/4	1/2	1		

3.1 Experimental Environment

In this experiment, the selected comparison object is the multiple linear regression teaching quality evaluation method, and the selected evaluation index is the fitting degree with the actual evaluation results. The higher the fitting degree is, the higher the evaluation accuracy of the evaluation method is, the more objective and accurate the online teaching quality of colleges and universities can be evaluated.

In this experiment, a teacher in a university is selected as the test object. Through the investigation of teaching effect and teaching content, the judgment matrix is constructed by using the teaching quality evaluation method, and the corresponding index weight value is calculated [12]. The online teaching quality evaluation data of the teacher in the first semester of 2021 is randomly selected as the standard to verify the accuracy of the evaluation method.

To make the judgment results of this paper more accurate and objective, 10 experienced teachers in the school were consulted to obtain the judgment matrix of teachers' teaching quality, as shown in the Table 3.

According to the teaching quality judgment matrix, the judgment weight is calculated to obtain the specific evaluation score. The accuracy of the two evaluation methods is compared by comparing the gap between the evaluation score obtained by the judgment method and the historical teaching quality evaluation data.

3.2 Experimental Results

According to the above test results, it can be seen that compared with the actual historical evaluation data, the traditional multiple linear regression evaluation method has a large difference in evaluation scores, with the maximum error of more than 10%, indicating that the traditional teaching quality evaluation method can not meet the evaluation needs of online university teaching quality in terms of evaluation accuracy. However, the online teaching quality evaluation method based on simulation analytic hierarchy process proposed in this paper is obviously superior to the traditional evaluation method in the fitting degree of evaluation results, and the evaluation accuracy difference is not more than 5%. It shows that the teaching quality evaluation method proposed in this paper has a high evaluation accuracy, and can make a scientific, accurate and objective evaluation of the online teaching quality of colleges and universities. This is because the evaluation method proposed in this paper is combined with the theory of the fuzzy analytic hierarchy process. Through the construction of the evaluation judgment matrix,

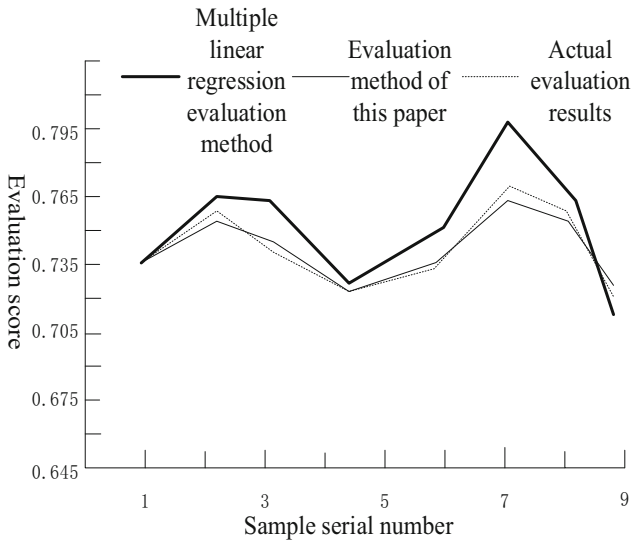

Fig. 1. Comparison of evaluation results

the weight value of evaluation index is calculated accurately, which can improve the accuracy of evaluation, reduce the subjective arbitrariness in evaluation, and effectively reflect the real level of online teaching quality in Colleges and universities, so that teaching managers can better understand the teaching state. It provides a scientific basis for the reform of teaching methods and other decision-making (Fig. 1).

4 Conclusion

The evaluation method of the online teaching quality in colleges and universities proposed in this paper is effectively combined with the fuzzy analytic hierarchy process. Through the construction of the evaluation index system, the level and direction of the evaluation are clarified. By constructing the evaluation judgment matrix, the weight value of each layer of the evaluation index is calculated. The evaluation result is scientifically calculated, which is beneficial to reducing the blindness and absoluteness of subjective factors on the evaluation result and obtaining a more accurate and scientific evaluation result. It is helpful to reflect the real teaching level of online teachers in Colleges and universities, and to improve the quality of teaching.

The fuzzy analytic hierarchy process can combine qualitative and quantitative methods, and overcome the interference of subjective factors to the greatest extent to evaluate the quality of teaching accurately and scientifically. In future research, how to fully feedback and use the conclusion of teaching evaluation, let teachers find the problems in teaching, reflect and improve teaching ideas and teaching methods, is a topic worthy of further study.

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