Research on the Construction of Classroom Teaching Evaluation System Based on Analytic Hierarchy Process

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Abstract

With the diversified and digital development of educational models, teaching quality needs more scientific evaluation. Teaching quality is not only related to the learning quality of students, but also related to the training of national talents. Objective and fair evaluation of classroom teaching quality is an important part of education. In order to evaluate the quality of classroom teaching scientifically, this paper uses analytic hierarchy process to evaluate the quality of classroom teaching. According to the rules of analytic hierarchy process, the high-quality classroom is the target level, the first and second level indicators are the criteria level, and the four classes are the scheme level. This paper calculates the weights of the first and second level classroom indicators, and constructs the classroom evaluation index system. Experts enter the classroom to score, and use the analytic hierarchy process to calculate and sort to get the optimal classroom. This paper provides a scientific calculation method for evaluating the quality of classroom teaching.

Keywords: AHP, Classroom teaching evaluation, High quality classroom

1   INTRODUCTION

Classroom is the main battlefield for students to learn knowledge, and the quality of classroom teaching will directly affect students' learning effect and growth. With the development of education digital age and the high requirement of teaching quality, classroom teaching evaluation has been paid more and more attention by the educational circle. From various teaching competitions to the regular teaching inspection of schools, how to evaluate each lesson objectively and fairly is related to the development of teaching quality and the quality of talent cultivation of students.

At present, in the evaluation of classroom teaching quality, the weight of scoring points is not scientific, with greater subjectivity and experience. The calculation process is simple and rough, and only the arithmetic mean weighted calculation is used, which is lack of scientificity in data processing. Objective and fair evaluation of classroom is an urgent problem to be solved.

In view of the above problems, this paper explores the use of analytic hierarchy process(AHP) to solve the problem of classroom evaluation. AHP can be used to objectively calculate the weight of each scoring point,

avoiding the subjectivity of weight and scientific calculation process. Using the multi-level consistency matrix, each index can be calculated without the problem of "large numbers eat small numbers" [8]. Each index is involved in the calculation, the results are more objective and fair. The following is a detailed introduction of AHP and its application in classroom evaluation.

2   OVERVIEW OF ANALYTIC HIERARCHY PROCESS

The Analytic Hierarchy Process (AHP) is a systematic and hierarchical evaluation method combining qualitative and quantitative methods. The objective layer, criterion layer and scheme layer constitute an evaluation system [2]. The criterion layer can be divided into several sub-criteria layers, and the criterion layer constitutes a comparative judgment matrix for the objective layer. Through the consistency test of the matrix, calculate whether the comparison matrix has consistency, if there is consistency, can calculate the weight of the matrix, so as to calculate the weight of each word criterion layer, after passing the consistency test, can calculate the total ordering of the scheme layer, criterion layer to the target layer. There are many

calculation data and a large amount of calculation. The calculation problem can be easily solved with the help of MATLAB software programming. The implementation steps are as follows.

2.1 Establishment of Hierarchy

First, analyze the problem elements to be solved, determine the elements of each level, and draw the hierarchical structure diagram, as shown in Figure 1. The top layer is the target layer, which is the best one among the many options. In the middle is the criterion layer, that is, the factors that affect the goal, generally including criteria and sub criteria. The more influence factors, the more complex the criterion is and the more complex the calculation is. The lowest layer is the solution layer, that is, the solution to the problem. In classroom evaluation, the optimal classroom is the target level, the indicators of the evaluated classroom are the criterion level, and each evaluated classroom is the scheme level.
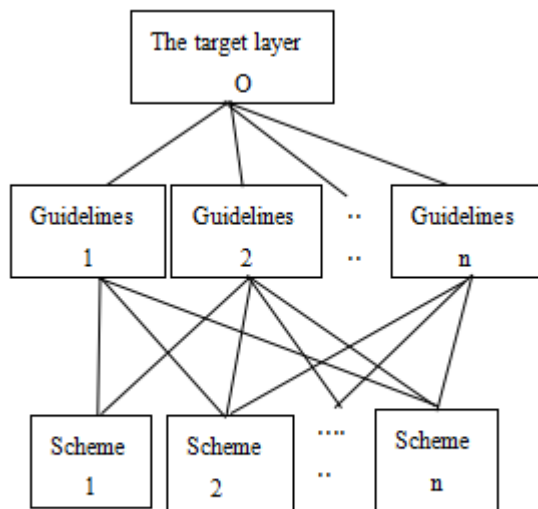

Figure 1: Hierarchy diagram

2.2 Construction of Judgment Matrix

According to the influence degree of the criterion layer on the target layer, several comparison matrices are constructed. Different comparison matrices can be constructed for the influence degree of the indicators at the same level on the upper level. In the classroom evaluation, the first level indicators are compared, and the comparison matrix is constructed by comparing the

impact on the target level. The secondary indicators are also compared, and the comparison matrix is constructed by comparing the impact on the primary indicators. Each primary indicator corresponds to different secondary indicators, so each primary indicator also corresponds to a comparison matrix.

2.3 Consistency Judgment of Comparison Matrix

If it is a consistency matrix, the relative weight vector can be further calculated; if it is not a consistency matrix, the comparison matrix should be reconstructed until the consistency matrix passes the test before the next calculation can be carried out. The characteristic root method, sum method or root method can be used to calculate the relative weight vector.

2.4 Consistency Test of Combined Weight Vectors

Calculate the consistency index of the comparison matrix $CI = \dfrac{\lambda_{max} - n}{n-1}$ .By a given random consistency indicator RI ,calculate the consistency ratio indicator $CR = \dfrac{CI}{RI}$,if $CR < 0.1$,Through consistency test, the weight vector can be used as the evaluation index weight. Then the same method is used to calculate the combination weight vector and verify the consistency [9]. If the consistency test is passed, the obtained vector is the sorting result of the scheme layer.

3 CLASSROOM EVALUATION PROCESS

There are four classes waiting for evaluation. In order to evaluate the class more objectively and fairly, we should first formulate evaluation indicators, then calculate their weights, and finally calculate the scores.

3.1 Establishment of Hierarchical Relationship

In the classroom evaluation, the high-quality classroom is the target level, the primary and secondary indicators are the criteria level, and the four classrooms are the scheme level, as shown in Table 1.

Table 1: Hierarchy diagram of classroom evaluation

Target layer O	Rule layer C	Subcriterion layer D	Scheme layer P
Quality class O	Class objective C1	Knowledge goal D11	Class 1
		Capability goal D12	
		Quality goal D13	
	Teaching process C2	Import new lesson D21	
		Teacher led D22	
		Student discussion D23	Class 2
		Work together to solve problem D24	
	Teaching methods C3	Online and offline mixed teaching D31	
		Information technology teaching D32	
		Heuristic and discussion methods D33	Class 3
		Combination of teaching and practicing D34	
	Teaching effect C4	Form good study habits D41	
		Develop the ability to solve problems independentlyD42	Class 4
	Teaching art C5	Teacher literacy D51	
		Classroom management D52	

The table is divided into three levels: target level, criterion level and scheme level. The target level is to select a high-quality class from the four classes. The criteria layer contains two levels of criteria. The first level of criteria contains five indicators, each of which contains different indicators and becomes a sub criteria layer. It can be seen from the table that each indicator of the first level indicator layer is not necessarily affected by the second level indicators of the next level, that is, a factor in the criteria layer only controls part of the factors of the next level, which is an incomplete hierarchy. In order to solve this problem, the relative weight of the non dominated index factors is reset to 0 in the calculation, and only the related factors are compared in the construction of the comparison matrix, and then the complete analytic hierarchy process is used to calculate [6].

3.2 Determination of Weight Vector from Standard Layer to Target Layer

First, determine the weight of primary indicators, and the calculation process is shown in Figure 2.
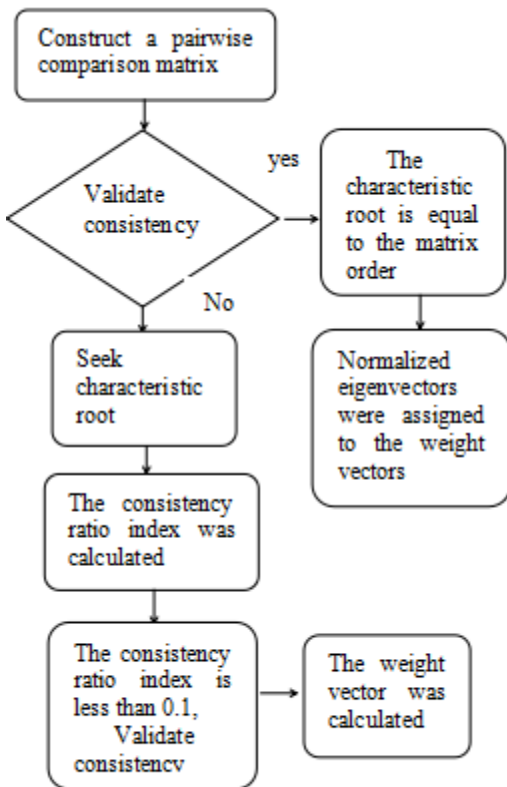

Figure 2 Flow chart of weight calculation

This calculation process plays an important role in the whole evaluation process [7]. It determines the weight vector of the criterion layer to the target layer, and lays a solid foundation for the calculation of the scheme layer to the target layer. MATLAB and other tool software can be used in the calculation. Although there are many data and complex steps, the calculation is fast and accurate. [3] This method of calculating weight comprehensively considers the factors that affect the target layer, making the results more scientific and objective. It has been applied to many problems related to evaluation.

3.2.1 Determination of Weight Vector of Primary Index

Construct the pairwise comparison matrix between the criterion layer and the target layer, as shown in Table 2.

Table 2: Judgment matrix about Ci to O

O	C1	C2	C3	C4	C5	$w^{(2)}$
C1	1	2	3	3	5	0.3022
C2	1/2	1	2	4	5	0.2619
C3	1/3	1/2	1	3	3	0.1799
C4	1/3	1/4	1/3	1	3	0.1666
C5	1/5	1/5	1/3	1/3	1	0.0894
Note: λ_{max}=5.05982; $CR^{(2)}$=0.0124625						

The eigenvalues and eigenvectors of this matrix are evaluated by the Matlab command as below:

C=[1 2 3 4 5;1/2 1 2 4 5;1/3 1/2 1 3 3;1/3 1/4 1/3 1 3;1/5 1/5 1/3 1/3 1]

[V, D]=eig(C)

Then, get: λ_{max}=5.05982,

Normalized weight vectors:

$$w^{(2)} = (0.3022, 0.2619, 0.1799, 0.1666, 0.0894)^{T}.$$

$$CI^{(2)} = \frac{5.05982-5}{5-1} = 0.014955$$

$$CR^{(2)} = \frac{CI^{(2)}}{RI^{(2)}} = \frac{0.014955}{1.12} = 0.0124625 < 0.1,$$

It can be seen from the table that the first-level indicator layer passes the consistency test, so it can be used as the weight vector of the criterion layer to the target layer.

3.2.2 Determination of Relative Weight Vector of Target Layer by Secondary Index

Because the first level indicators are not affected by all the second level indicators, only the pairwise comparison matrix of the second level indicators under the first level indicators is constructed. Since there are five primary indicators, the five comparison matrices are constructed as shown in Table 3, 4, 5, 6 and 7 below.

Table 3: Judgment matrix about D1i to C1

C1	D11	D12	D13	$\tilde{w}_1^{(3)}$
D11	1	1	1/2	0.25
D12	1	1	1/3	0.15
D13	2	3	1	0.6
Note: λ_{max}=3; C.R.=0				

Table4: Judgment matrix about D2i to C2

C2	D21	D22	D23	D24	$\tilde{w}_2^{(3)}$
D21	1	5	1	3	0.394
D22	1/5	1	1/5	1/2	0.075
D23	1	5	1	3	0.394
D24	1/3	2	1/3	1	0.138
Note: λ_{max}=4.004; C.R.=0.001					

Table5: Judgment matrix about D3i to C3

C3	D31	D32	D33	D34	$\tilde{w}_3^{(3)}$
D31	1	3	3	1	0.375
D32	1/3	1	1	1/3	0.125
D33	1/3	1	1	1/3	0.125
D34	1	3	3	1	0.375
Note: λ_{max}=4; C.R.=0					

Table6: Judgment matrix about D4i to C4

C4	D41	D42	$\tilde{w}_4^{(3)}$
D41	1	3	0.933
D42	1/3	1	0.067
Note: λ_{max}=3; C.R.=0			

Table7: Judgment matrix about D5i to C5

C5	D51	D52	$\tilde{w}_5^{(3)}$
D51	1	4	0.85
D52	1/4	1	0.15
Note: λ_{max}=2; C.R.=0			

It can be seen from the above tables that all passed the conformance test.

The relative weight vectors of the 15 indicators in the sub-criterion layer to the first-level indicators are respectively:

$$w_1^{(3)} = (0.25,0.15,0.6,0,0,0,0,0,0,0,0,0,0,0,0)^T,$$
$$w_2^{(3)} = (0,0,0,0.394,0.075,0.394,0.138,0,0,0,0,0,0,0,0)^T,$$
$$w_3^{(3)} = (0,0,0,0,0,0,0,0.375,0.125,0.125,0.375,0,0,0,0)^T,$$
$$w_4^{(3)} = (0,0,0,0,0,0,0,0,0,0,0,0.933,0.067,0,0)^T,$$
$$w_5^{(3)} = (0,0,0,0,0,0,0,0,0,0,0,0,0,0.85,0.15)^T$$

The matrix consisting of them as the column vectors is:

$$W^{(3)} = (w_1^{(3)}, w_2^{(3)}, w_3^{(3)}, w_4^{(3)}, w_5^{(3)}),$$

Combined weight of the secondary indicators on the target layer:

$$w^{(3)} = W^{(3)}w^{(2)} = (0.164,0.031,0.164,0.057,0.065,0.065,0.131,$$

$$0.0134,0.027,0.037,0.012,0.012,0.037,0.047,0.016)^T$$

Combination consistency test of second-level indicators on target layer:

$$CR^{(3)} = CR^{(2)} + \frac{CI^{(3)}}{RI^{(3)}} = 0.01595 < 0.1$$
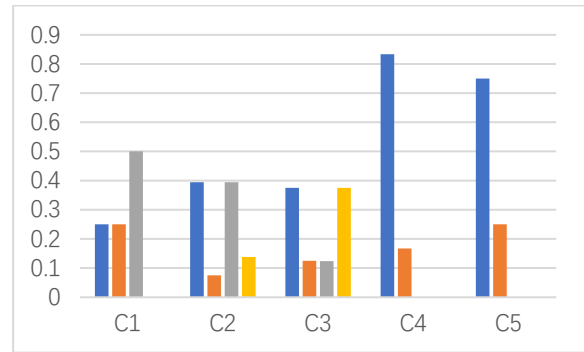
The weight ratio is shown in Figure 3.

Figure 3: The weight ratio of the 15 indicators

It can be seen from the above table that the secondary indicators have passed the combination consistency test for the target layer, and these 15 weights can be used as the weights of the 15 indicators of the secondary indicators for the target layer. After the judge scores the 15 indicators, the relative weight vector of each factor of the scheme layer to the sub criterion layer can be calculated. In this step, a scientific and reasonable evaluation index weight system is formulated, which is an important content in the evaluation process, a scientific basis for classroom evaluation, and of great significance to classroom evaluation. [1]

3.3 Determination of Relative Weight Vector of Scheme Layer to Criterion Layer

According to the weight calculated above, the evaluation experts give the scores of the second-level indicators for the four classes, so a pairwise comparison matrix for the second-level indicators can be constructed for each class. According to the construction method of matrix, this matrix is a consistency matrix, the maximum characteristic root is 4, and the consistency index is 0. The relative weight vector of each class to the second-level index can be obtained by normalization of any column vector, taking the relative weight vector of each class to the second-level index as the column vector, $W^{(4)} = (w_1^{(4)}, w_2^{(4)}, \cdots, w_{15}^{(4)})$,the weight vector matrix of each class to the second-level index can be obtained [4].

3.4 Determination of Combination Weight Vector of Scheme Layer to Target Layer

The combination weight vector of the scheme layer to the target layer is obtained by multiplying the previously calculated relative weight vector of the scheme layer to the sub criterion layer by the combination weight vector of the sub criterion layer to the target layer. Then calculate the consistency inspection index of the scheme layer to the target layer [5].

$$w^{(4)} = W^{(4)}w^{(3)} = (0.1912, 0.3025, 0.3231, 0.1837)^T$$

The results are shown in the following Figure 4.
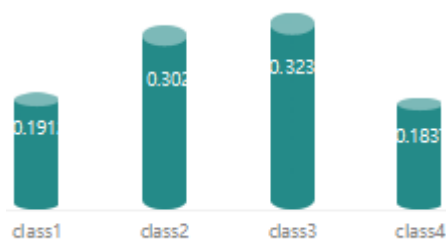
Figure4: Course ranking results

This combination weight is the final score weight of the four classes. It can be seen that Class 3 is the best class.

4 CONCLUSIONS

Analytic hierarchy process (AHP) is more scientific in calculating the indicators of the criterion level in the evaluation of classroom teaching, and removes the subjective factors that give weight artificially. It turns the qualitative problems and subjective factors in the evaluation into quantitative problems and objective factors. In the calculation, each index is carefully compared and added to the calculation. The consistency test proves that the calculation of weight is objective and fair, which provides a scientific calculation method for classroom evaluation. With the enrichment of teaching means and teaching resources such as digitalization and informatization, teaching indicators will further change. The previous simple and rough evaluation methods are more unsuitable for the development of the times. Therefore, analytic hierarchy process can play a relatively objective and fair evaluation. With the progress of science and technology, the evaluation methods of classroom teaching will be more fair in the future.

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