Research on Badminton Education Teaching Quality Evaluation System Based on Fuzzy Analytic Hierarchy Process

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Abstract. In order to evaluate the teaching quality of the badminton teachers and improve the teaching quality, in this article, the fuzzy analytic hierarchy process is used to establish badminton teaching quality evaluation system. We evaluate the teaching quality from four aspects such as teaching attitude, teaching content, teaching method and teaching effect and establish a three layer hierarchical structure. After constructing a fuzzy consistency matrix, we obtain the weights of the indicators in all layers and the combined weights of the indicators in the bottom layer. The comprehensive indicator calculated from the combined weight can reflect the teaching quality of the badminton teacher. By using the theory of fuzzy sets, the weights of the indicators can be determined so that the evaluation result can be more scientific. This system offsets the shortage of the badminton education teaching quality evaluation, which can improve the badminton education and its teaching quality.

Introduction

Badminton education teaching quality evaluation is the significant method to evaluate the teaching comprehensive level of the teachers and is the main approach to manage the badminton teaching scientifically. We usually combine expert evaluation, colleague peer assessment and students appraising teaching to evaluate the teaching quality of badminton teachers. The human factor can influence the evaluation result and make it different from the practical situation, which can not reflect the authenticity and justification. Even it may influence the teaching enthusiasm, which is bad to the teaching process. As a PE course, badminton curriculum is different from other theoretical ones. It is implemented on the playground. The students are of different levels. So it is difficult to determine the factors in the process of teaching evaluation. It is not realistic to quantify all the determined factors. So we will use the qualitative and quantitative methods to implement the badminton teaching quality evaluation. Some scholars use AHP to study PE teaching quality evaluation. But the traditional AHP usually uses Saaty's weight method to determine the weights of all the indicators and asks the pairwise comparison judgment matrix to have satisfactory consistency. In practice, when the exponent number is larger, the consistency of judgment matrix isn't always satisfactory. So the established education teaching evaluation system has problems. In the overall PE system teaching quality evaluation, there is no badminton teaching quality evaluation research. Different PE course has different characters, so using same evaluation indicator system can not reflect the teaching quality of the teachers. In order to offset the shortage of the research of badminton teaching quality evaluation and the disadvantage of the traditional evaluation method, we use fuzzy analytic hierarchy process to evaluate the badminton education teaching quality, which can provide reference for badminton education teaching quality evaluation.

Summary of Fuzzy Analytic Hierarchy Process

A. Fundamental Principle of Fuzzy Analytic Hierarchy Process

Fuzzy analytic hierarchy process can offset the difficulties and unscientific problems caused when AHP assesses the consistency of judgment matrix. The principle of Fuzzy AHP is almost the same with that of AHP. Fuzzy AHP uses qualitative analysis and quantitative analysis at the same time, which can systemize, qualify and model the complicated problems. This means that we should resolve the complicated problem into several elements and then the elements should be further resolved into more specific, detailed and quantified small elements (indicators). According to the significance, the weights of the elements should be determined. Then we use the weights to connect the layers to establish a statistical model with multiple targets and multiple layers. Fuzzy AHP and traditional AHP have two differences. One is that AHP establishes judgment matrix by pairwise comparison of all the indicators and test the consistency of the matrix, but Fuzzy AHP establishes fuzzy consistency matrix by pairwise comparison of all the indicators without the test of the consistency. The second difference is the calculation methods of indicator weights.

B. The Basic Steps of Fuzzy AHP

The basic steps of Fuzzy AHP is similar to traditional AHP, which is shown as below,

1) Establish a multi-layer hierarchical structure, forming a target tree diagram.

Fuzzy AHP includes three layers which are top layer, middle layer and bottom layer. Please see Fig. 1. The top layer is the target layer which is overall target of AHP. The middle layer is also called constrained layer which includes some factors influencing the overall target. The bottom layer is called measurement layer which includes the final measurement. The measurement can solve the problem and can be quantified.

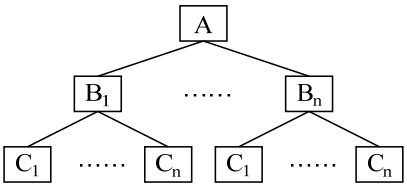

Figure 1. Model structure of AHP

2）Construct Fuzzy Consistency Matrix.

We use R to represent fuzzy consistency judgment matrix. First we choose one indicator in the upper layer and determine the related indicator in the lower layer. Compare the relative significances of the indicators. Suppose the indicator C in the upper layer can be explained by indicator $a_1, a_2, \cdots, a_n$ in the lower layer. Then we can construct a fuzzy consistency judgment matrix which is shown in table 1.

TABLE I. FUZZY CONSISTENCY JUDGMENT MATRIX

C	a_1	a_2	$\cdots$	a_n
a_1	r_{11}	r_{12}	$\cdots$	r_{1n}
a_2	r_{21}	r_{22}	$\cdots$	r_{2n}
$\cdots$	$\cdots$	$\cdots$	$\cdots$	$\cdots$
a_n	r_{n1}	r_{n2}	$\cdots$	r_{nn}

$r_{ij}\,(i=1,2,\cdots,n;\ j=1,2,\cdots,n)$ represents the proportion of degree of significance between a_i and a_j which are the ith indicator and jth indicator of C in the upper layer. In order to quantify the degree of importance, we will use the following grading standard shown in Table 2.

TABLE II. THE GRADING STANDARD IN EACH LAYER OF FUZZY AHP

The importance scale r_{ij}	**Relative degree of importance**	**Instruction**
0.5	Equally important	The two indicators are equally important after comparison.
0.6	Somewhat important	One indicator is somewhat important than the other after comparison.
0.7	Obviously important	One indicator is obviously important than the other after comparison.
0.8	Indeed important	One indicator is indeed important than the other after comparison.
0.9	Absolutely important	One indicator is absolutely important than the other after comparison.
0.1,0.2,0.3,0.4	Converse comparison	If the importance ratio between a_i and a_j is r_{ij}, the importance ratio between a_j and a_i is $r_{ji} = 1 - r_{ij}$.

According to the scoring method in Table 2, after the pairwise comparison of evaluation indicators $a_1, a_2, \cdots, a_n$ of indicator C, we can get fuzzy judgment matrix shown below,

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{nn} \end{bmatrix}$$

This matrix has three properties which are

$$(1)\ r_{ii} = 0.5, i = 1,2,\cdots,n;$$
$$(2)\ r_{ij} = 1 - r_{ji}, i, j = 1,2,\cdots,n;$$
$$(3)\ r_{ij} = r_{ik} - r_{jk}, i, j, k = 1,2,\cdots,n.$$

3）Calculate the weights of all the indicators

Suppose the weight set of indicators $a_1, a_2, \cdots, a_n$ is $W = (\omega_1, \omega_2, \cdots, \omega_n)$, then

$$r_{ij} = 0.5 + a(\omega_i - \omega_j),\ \ i,j = 1,2,\cdots,n$$

In the formula, $0 < a \le 0.5, a$ is the evaluation which the evaluator imposes on the evaluation objects.

When R is not consistent, the above formula is not strictly true and we can use the least squares principle to obtain weight vector $W = (\omega_1, \omega_2, \cdots, \omega_n)$, which shown in below,

$$\begin{cases} \min z = \sum_{i=1}^{n}\sum_{j=1}^{n}[0.5 + a(\omega_i - \omega_j) - r_{ij}]^2 \\ s.t. \sum_{i=1}^{n}\omega_i = 1, \omega_i \ge 0, (1 \le i \le n) \end{cases} \qquad (1)$$

According to Lagrange's theorem, the above formula and the below one is equal in value.

$$\min L(\omega, \lambda) = \sum_{i=1}^{n}\sum_{j=1}^{n}[0.5 + a(\omega_i - \omega_j) - r_{ij}]^2 + 2\lambda(\sum_{i=1}^{n}\omega_i - 1)$$

And λ in the formula is the Lagrange multiplier.

Calculate the partial derivative of $\min L(\omega, \lambda)$ with $\min L(\omega, \lambda)$ and suppose it equals to zero. Then we can get the following equations.

$$a\sum_{j=1}^{n}[0.5 + a(\omega_i - \omega_j) - r_{ij}] - a\sum_{k=1}^{n}[0.5 + a(\omega_k - \omega_i - r_{ki}] + \lambda = 0 \qquad (2)$$
$$(i = 1,2,\cdots,n)$$

The equations are equivalent to the following equations

$$\sum_{j=1}^{n}[2a^2(\omega_i - \omega_j) + a(r_{ji} - r_{ij}) + \lambda = 0 \qquad (3)$$
$$(i = 1,2,\cdots,n)$$

The number of unknown number is n+1 which is $\omega_1, \omega_2, \cdots \omega_n, \lambda$. The number of equations is n+1.

$$\begin{cases} 2a^2(n-1)\omega_1 - 2a^2\omega_2 - 2a^2\omega_3 - \cdots - 2a^2\omega_n + \lambda = a\sum_{j=1}^{n}(r_{1j} - r_{j1}) \\ -2a^2\omega_1 + 2a^2(n-1)\omega_2 - 2a^2\omega_3 - \cdots - 2a^2\omega_n + \lambda = a\sum_{j=1}^{n}(r_{2j} - r_{j2}) \\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \\ -2a^2\omega_1 - 2a^2\omega_2 - 2a^2\omega_3 - \cdots + 2a^2(n-1)\omega_n + \lambda = a\sum_{j=1}^{n}(r_{nj} - r_{jn}) \\ \omega_1 + \omega_2 + \cdots + \omega_n = 1 \end{cases} \quad (4)$$

After solving the equations, we can get the weights of the evaluation indicators.

4）Calculate the combined weight C_i of the indicators in the bottom layer by using weighting method.

C_i = Indicator Weights of Layer B * Indicator Weights of Layer C

5）Calculating Comprehensive Index *GI*

If there are low priority indicators and high priority indicators in the selected evaluation indicators, we should implement convergence process. The method is as follows. High priority indicator Pi = actual value/desired value; low priority indicator Pi = desired value / actual value. After the convergence process, we calculate the comprehensive index $GI = \sum_{j=1}^{m} C_i P_i$.

Establishment of Badminton Education Teaching Quality Evaluation System

The Selection of Evaluation Indicators

The badminton education teaching quality evaluation system is comparatively complicated and there are a lot of influential factors. So the establishment of badminton education teaching quality evaluation system is a big project. The selection of the evaluation indicators will influence the evaluation system. In order to select the indicators of badminton education teaching quality evaluation system more comprehensively, systematically and scientifically and improve the accuracy of the evaluation, we should make the indicators more scientifically and practically. In the process of selection of the indicators, we should regard target guidance quality, scientificity, globality, objectiveness and practicality as the basic principles. Combining with the basic theory and the teaching practice, from the aspects of teaching attitude, teaching content, teaching method and teaching effects, we preliminarily select the factors which influence badminton education teaching quality evaluation system as the indicators. After selecting the indicators, we have consulted the professors engaging in the badminton teaching, experts engaging in teaching management and theoretical research. With their opinions, we select teaching attitude, teaching content, teaching method and teaching effect as the indicators of PE teaching evaluation system. Then each indicator is resolved into different indicators and we establish a three-layer hierarchical structure which shown in Table 3.

TABLE III. BADMINTON EDUCATION TEACHING QUALITY EVALUATION INDICATORS SYSTEM

First Level Indicator A	Second Level Indicator B	Third Level Indicator C
Education Teaching Quality A	Teaching Attitude B1	Teaching Plan Preparation C1
		Teaching Term Plan C2
		To Be in Class and Finish Class on Time C3
		Training After Class C4
	Teaching Content B2	Rationality of Contents C5
		Cohesion of Contents C6
		Utilization of Supplementary Contents C7
	Teaching Method B3	Scientificity C7
		Innovation C9
		Variety C10
	Teaching Effect B4	Ability Improvement of Students C11
		Test Scores of Students C12
		Educational Attraction C13

Establishment of Fuzzy Consistency Matrix

According to the above mentioned establishment method of fuzzy consistency matrix, we establish the fuzzy consistency matrixes of each layer.

TABLE IV. FUZZY CONSISTENCY MATRIX OF FIRST LEVEL INDICATORS

A	B1	B2	B3	B4
B1	0.5	0.8	0.7	0.6
B2	0.2	0.5	0.4	0.3
B3	0.3	0.6	0.5	0.4
B4	0.4	0.7	0.6	0.5

TABLE V. FUZZY CONSISTENCY MATRIX OF SECOND LEVEL INDICATORS (TEACHING ATTITUDE)

B1	C1	C2	C3	C4
C1	0.5	0.5	0.3	0.4
C2	0.5	0.5	0.3	0.4
C3	0.7	0.7	0.5	0.6
C4	0.6	0.6	0.4	0.5

TABLE VI. FUZZY CONSISTENCY MATRIX OF SECOND LEVEL INDICATORS (TEACHING CONTENT)

B2	C5	C6	C7
C5	0.5	0.6	0.7
C6	0.4	0.5	0.6
C7	0.3	0.4	0.5

TABLE VII. FUZZY CONSISTENCY MATRIX OF SECOND LEVEL INDICATORS (TEACHING METHOD)

B3	C8	C9	C10
C8	0.5	0.6	0.6
C9	0.4	0.5	0.5
C10	0.4	0.5	0.5

TABLE VIII. FUZZY CONSISTENCY MATRIX OF SECOND LEVEL INDICATORS (TEACHING EFFECT)

B4	C11	C12	C13
C11	0.5	0.7	0.8
C12	0.3	0.5	0.6
C13	0.2	0.4	0.5

Calculating the Weights of Indicators

According to formula (4), we construct equations of each fuzzy consistency matrix. Then we use Matlab software to program and get the weights of the indicators in the matrixes.

The weight vector of second level indicators in the badminton education teaching quality is $W_1 = [0.323, 0.177, 0.226, 0.274]^T$.

The weight vector of the evaluation indicator in second level indicator teaching attitude is $W_2 = [0.213, 0.213, 0.311, 0.262]^T$.

The weight vector of the evaluation indicator in second level indicator teaching content is $W_3 = [0.4, 0.333, 0.267]^T$.

The weight vector of the evaluation indicator in second level indicator teaching method is $W_4 = [0.35, 0.3, 0.35]^T$.

The weight vector of the evaluation indicator in second level indicator teaching effect is $W_5 = [0.444, 0.311, 0.244]^T$.

So we can get badminton education teaching quality evaluation system which is shown in Table 9.

TABLE IX. BADMINTON EDUCATION TEACHING QUALITY EVALUATION SYSTEM

First Level Indicator A	Second Level Indicator B	Weight	Third Level Indicator C	Weight	Combined Weight
Education Teaching Quality A	Teaching Attitude B1	0.323	Teaching Plan Preparation C1	0.213	0.069
			Teaching Term Plan C2	0.213	0.069
			To Be in Class and Finish Class on Time C3	0.311	0.1
			Training After Class C4	0.262	0.085
	Teaching Content B2	0.177	Rationality of Contents C5	0.4	0.071
			Cohesion of Contents C6	0.333	0.059
			Utilization of Supplementary Contents C7	0.267	0.047
	Teaching Method B3	0.226	Scientificity C7	0.35	0.079
			Innovation C9	0.3	0.068
			Variety C10	0.35	0.079
	Teaching Effect B4	0.274	Ability Improvement of Students C11	0.444	0.122
			Test Scores of Students C12	0.311	0.085
			Educational Attraction C13	0.244	0.067

According to the combined weight of indicators in the bottom layer of the evaluation system, we can calculate the comprehensive index GI of the badminton teachers. According to the values of GI, we can rank and evaluate the education teaching quality of the badminton teachers.

Conclusion

In this research, fuzzy analytic hierarchy process is used to establish badminton education teaching quality evaluation system. This method scientifically quantifies all the evaluation indicators. We establish fuzzy consistency matrix to analyze the importance degree of the indicators and obtain a comparatively good research result. This evaluation system offsets the shortage of the badminton education teaching quality evaluation, which can improve the badminton education and its teaching quality.

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