International Journal of Engineering Sciences & Research Technology

(A Peer Reviewed Online Journal)
Impact Factor: 5.164

IJESRT

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

CASE-BASED TEACHING PERFORMANCE EVALUATION SYSTEM AND AN IMPROVED ANALYTIC HIERARCHY PROCESS MODEL USING LINGUISTIC VARIABLES

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DOI: 10.5281/zenodo.3742956

ABSTRACT

With the emergency of "Internet + teaching" in China, the evaluation of blending teaching has become more and more urgent. This study combines data from experts and database of Teaching Management System, and employs the improved Analytic Hierarchy Process (AHP) method to establish a scientific teaching performance evaluation model. First, linguistic variables were adopted to assess the online and offline mixed course characteristics to construct the teaching quality evaluation system. Second, fuzzy AHP (FAHP) was utilized to determine the factors' weights, meanwhile, a novel synthesizing algorithm, based on the range of each scheme, is proposed to deal with the dependencies between schemes, therefore settle the problem caused by the traditional calculating method. Third, this study applies FAHP to calculate the final ranking and makes the analyzing process more systematic and concise. Through a real case study, we find the evaluation results of the model are consistent with the ranking of the teaching competition fairly well, thus the reliability of this method is verified. To sum up, this study presents a high reliable improvement of FAHP, and also provides a complete set of solutions for evaluating blending teaching.

KEYWORDS: fuzzy analytic hierarchy process, fuzzy pairwise comparison matrix, Internet+ teaching, teaching performance evaluation.

1. INTRODUCTION

With the development of information technology, quite a lot of teaching methods have been introduced to make the class more attractive and expressive. In China, employing MOOC (Massive Open Online Courses) and SPOC (Small Private Online Course) to assist teaching is a reform direction that is widely supported by the government and universities. Blending course integrates online and offline teaching, which brings a new experience to students. For colleges, cultivating high-quality talents requires not only advanced teaching technology but also a scientific teaching evaluation system. Now, the widespread blending teaching has also brought new challenges to teaching quality monitoring and teaching evaluation, for the existing evaluation systems and methods are designed for traditional teaching models. Effective teaching evaluation could encourage teachers to improve their teaching methods and thus provide a better classroom experience. However, the evaluation of teaching will inevitably contain people's subjective views, which are uncertain and unreliable. Therefore, it is of great significance to adopt a scientific and effective method to establish a feasible teaching quality evaluation system.

Considering that building a fair and scientific evaluation method is the most important part of teaching performance examination, some previous researches are devoted to constructing a teaching quality evaluation index system with both qualitative and quantitative method. Previous research proposed by Saaty[1] has established a simple, flexible and practical multi-criteria decision-making method which is called the Analytic Hierarchy Process for quantitative analysis of qualitative problems. Due to AHP's advantages, some studies apply this method to the teaching quality evaluation system. During AHP, decision-makers can consider and

ISSN: 2277-9655
Impact Factor: 5.164
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measure factors' related importance, using a quantitative method to make the result much more accurate and reasonable.

Qi Yan-ming[2]constructed a teaching quality evaluation index system which is based on AHP and fuzzy comprehensive evaluation. And the result of the comprehensive evaluation reveals that this evaluation system can provide an innovative method to evaluate teaching performance, and it has both theoretical and practical value. In Thanassoulis's paper[3], an integrated approach was proposed to address some issues in traditional student evaluation of teaching. This method combines AHP and data envelopment analysis (DEA), and thus identifies what teachers need to improve. Huang[4] has proposed the RAHP Topsis method which combined the AHP method and the TOPSIS method, thereby evaluating the teaching performance reasonably. The evaluation results demonstrate that this evaluating method is scientific.

The above studies revealed that methods applying AHP can build an effective and accuracy teaching quality evaluation system. However, merely utilizing the AHP method can not address those complex problems and can not express human's vague comparison about those decisions. Hence it is meaningful to apply the fuzzy AHP theory in quantitatively describing the factors that affect teaching quality evaluation.

A previous study conducted by Chang[5] has employed the extent analysis method on FAHP. The use of triangular fuzzy numbers for pairwise comparison scales of fuzzy AHP can improve comprehensive evaluation, thus making the FAHP method become much more reliable. Shi Sanyuan[6] has constructed a CDIO model which is based on AHP and fuzzy judgment to evaluate classroom teaching quality. The result of this CDIO evaluation model can reflect the management of teaching quality more objectively. In Chen and Jeng-Fung's paper[7], FAHP was utilized to estimate factor and sub-factor weights and received a reliable index system. Then apply a fuzzy comprehensive evaluation method to measure the final score. The application of this framework can make the evaluation results more scientific, accurate, and objective. Zhou[8] applied a new method of FAHP based on a triangular incenter point to estimate the factor's weights in the multifactorial evaluation. This evaluation method is meaningful and valid for teaching quality examination.

However, these previous studies have some common shortcomings. First, most researches would build the evaluation system for offline course teaching, while there has been little index system to assess those online and offline mixed courses. In this article, the assessment system will consider both online and offline teaching factors, of which MOOC will take a third of the whole system. Second, previous studies[9] have recognized that there may be some defects in the traditional AHP method, which would be expressed in the following chapter. We improved the AHP method, making the final ranking much more reliable and stable. The final shortage of the foregoing researches is that all these studies apply fuzzy comprehensive evaluation when determining the final score. In comprehensive evaluation, the determination of the index weight vector is highly subjective and related. Employing the improved FAHP method to calculate the final order would be more systematic and practical.

2. ANALYTIC HIERARCHY PROCESS AND ITS IMPROVEMENT

2.1. Comprehensive Score Calculation in AHP

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Analytic hierarchy process is a commonly used algorithm for analyzing multi-objective evaluation and multi-index decision-making problems. However, the traditional AHP has a certain potential defect while calculating comprehensive scores. This defect is due to the loss of independence of each scheme. Typically, the problem is that if the schemes in the bottom layer were adjusted, the final output would be inconsistent with the original result. For example, given 4 schemes A_1, A_2, A_3, A_4 for sorting, the result derived from AHP is $A_1 > A_2 > A_3 > A_4$. Again, if A_4 was removed from the options, the obtained results would possibly be not $A_1 > A_2 > A_3$ as excepted, it might be $A_1 > A_3 > A_2$ This is the problem of traditional AHP, and some measures should be taken to deal with this.

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Impact Factor: 5.164
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Kong[9] also noticed this issue and gave some valuable suggestions in his study. Kong pointed out that the each scheme's weights need to be changed to relative weights in order to be consistent with the relative importance of the indicator. Kong proposed the ideal scheme, and recalculated the weights of each scheme in order to make them independent. Our solution which would address the potential problems in AHP is based on Kong's method, and makes some improvements. The innovation is that the new weight is divided by the range of schemes, instead of the biggest value. The following content would explain the origin of this method and demonstrate the specific algorithm.

According to the traditional AHP, after several weight calculation steps, the whole weight matrix, as shown in Table 1 can be obtained. In other words, the weights of the upper-level factors have been determined, they are $a_1, a_2, ..., a_m$ for factors $A_1, A_2, ..., A_m$, and the weights of the sub-factors within each factor have also been determined. For A_i's sub-factor $B_1, B_2, ..., B_n$, the weights are $b_{1j}, b_{2j}, ..., b_{nj}\ (j = 1, 2, ..., m)$.

$$\sum_{j=1}^{m} a_j b_{ij}, i = 1, 2, ..., n \qquad \text{(i)}$$

Table 1.Comprehensive score for ranking

Factors	A_1	A_2	…	A_m	Comprehensive Score
	a_1	a_2	…	a_m	
B_1	b_{11}	b_{12}	…	b_{1m}	$\sum_{j=1}^{m} a_j b_{1j}$
B_2	b_{21}	b_{22}	…	b_{2m}	$\sum_{j=1}^{m} a_j b_{2j}$
…	…	…	…	…	…
B_n	b_{n1}	b_{n2}	…	b_{nm}	$\sum_{j=1}^{m} a_j b_{nj}$

In Table 1, $\sum_{i=1}^{n} b_{ij} = 1$ means the sum of the importance of each sub-factor (scheme) of factor j is 1. $\sum_{j=1}^{m} a_j = 1$ means the sum of weights is 1. a_j is the weight of each factor, $A_1, A_2, ..., A_m$. However, according to Eq.1, a_j should be the relatively important measure of each scheme for the indicator. This contradicts the original intention of AHP. So, there exists a problem while calculating the comprehensive score for ranking.

In addition, AHP normalizes the relative importance measure of each scheme for one factor. This means that the more options a factor has, the less importance of each option can be assigned. When the number of schemes n is increased or decreased, their absolute values (b_{ij}) are changing. Although the relative proportions of the schemes were not changed, it would still cause the final ranking results to vary with changes of n. In fact, the schemes are independent of each other, so the ranking of the schemes should not be affected by other schemes. That is, for the calculation of the relative importance measure of each scheme for a factor, the normalization step does not make sense.

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Therefore, in the following chapter, we will use an example to prove the defects in traditional AHP, and innovate a measure to maintain independence between schemes. This method is to construct an ideal scheme weight, and then divide each scheme by the ideal value to get a new scheme ranking. The innovation of this article is using the range to represent the ideal solution.

2.1.1An Example

An enterprise intends to take an action to promote its further development. The decision makers of this enterprise employ the AHP method and establishes hierarchy model as shown in Figure 1.

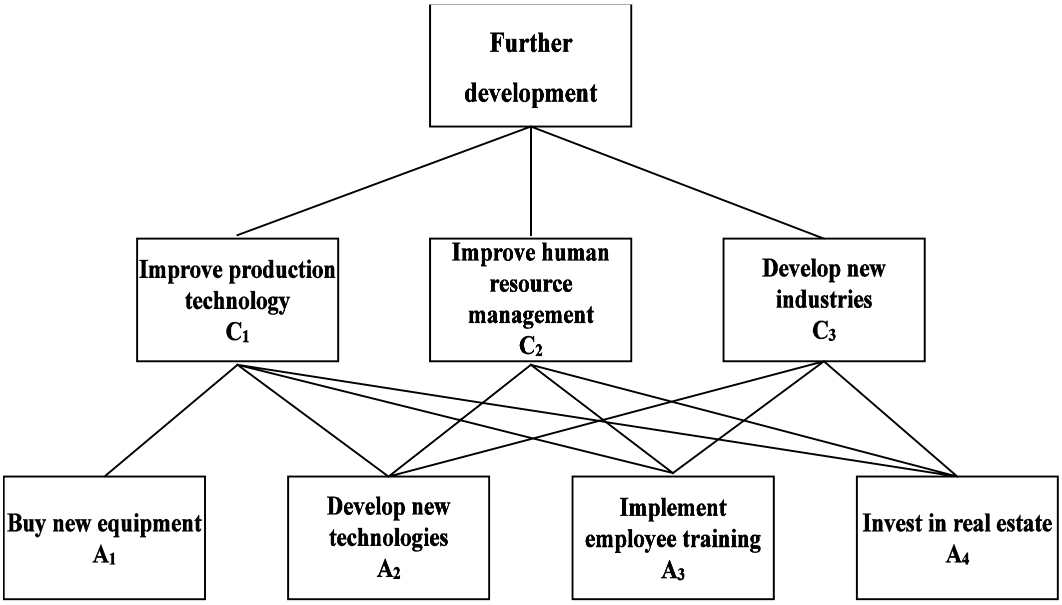

Figure 1.The AHP hierarchy model for the company

According to AHP algorithm, weights in higher level and relative weights of each scheme for each factor can be calculated out, as in Table 2,Table 3,Table 4,Table 5. Also, the result weight matrix is constructed which is shown in Table 6.

Table 2.Weights between three factors

Factors	C_1	C_2	C_3	Weight
C_1	1	0.2	2.5	0.191
C_2	5	1	5	0.705
C_3	0.4	0.2	1	0.104

Table 3.Weights of each scheme relative to C1

C_1	A_1	A_2	A_3	A_4	Weight
A_1	1	3	3	5	0.503
A_2	0.333	1	1	5	0.213
A_3	0.333	1	1	6	0.227
A_4	0.2	0.2	0.167	1	0.057

Table 4.Weights of each scheme relative to C2

C_2	A_2	A_3	A_4	Weight

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A_2	1	0.143	0.333	0.081
A_3	7	1	5	0.731
A_4	3	0.2	1	0.188

Table 5.Weights of each scheme relative to C3

C_3	A_2	A_3	A_4	Weight
A_2	1	1	5	0.454
A_3	1	1	5	0.454
A_4	0.2	0.2	1	0.091

Table 6. Ranking of various schemes

Factors	C_1	C_2	C_3	Comprehensive Score	Ranking
	0.191	0.705	0.104		
A_1	0.503	0	0	0.096	4
A_2	0.213	0.081	0.455	0.145	3
A_3	0.227	0.731	0.455	0.606	1
A_4	0.057	0.188	0.091	0.153	2

The result ranking of each scheme is: $A_3 > A_4 > A_2 > A_1$. This time, if scheme A_1 could not be implemented for some reason, the remaining ranking results of each scheme should be $A_3 > A_4 > A_2$ based on the current conclusion.

However, if we repeat the above calculation process only changing the options from A_{1-4} to A_{2-4}, the result is inconsistent with what we expected. This result is $A_3 > A_2 > A_4$ as is listed in Table 7, which is different from the previous one.

Table 7. Ranking of schemes removing A1

Index	C_1	C_2	C_3	Scheme Weight	Scheme Ranking
	0.191	0.705	0.104		
A_2	0.444	0.081	0.455	0.189	2
A_3	0.472	0.731	0.455	0.653	1
A_4	0.084	0.188	0.091	0.158	3

2.1.2The Improved Method

In the weight matrix shown in Table 1, if we examine a certain factor, we can find that it depends on multiple sub-factors at the lower layer and the degrees are indicated by weights. When some schemes are inserted or deleted, the absolute value of the weights has changed. Taking the normalized factor as an example, any operation of adding or deleting schemes will cause the quota of other schemes to decrease or increase. Is this reasonable? Each scheme should be independent, and if the independence of the schemes is guaranteed, such problems can be controlled.

Therefore, the improved AHP is intended to solve this problem. In the evaluation system, the factor's importance is relative to the index j. For the scheme level, the weight of the scheme is relative to the index in the first level, which is not consistent. If the weight of the scheme is relative to one scheme, the problem will be solved. To eliminate the influence from other schemes, we improved the key step by introducing an ideal scheme.

The improved method's steps are:
1) Establish a hierarchical structural model;
2) Construct the weight matrix via AHP calculation;
3) Determine the ideal scheme and name it A^*. A^*'s weight is defined as the range of weight of each scheme:

$$b_j^* = b_{j\max} - b_{j\min} \quad \text{(ii)}$$

4) Let the total utility $U(A^*)$ of the ideal plan be 1 and calculate the total utility $U(A_i)$ of each plan as:

$$U(A_i) = \sum_{j=1}^{m} a_j \cdot \frac{b_{ij}}{b_j^*} \quad \text{(iii)}$$

5) The schemes are arranged according to the order of U (A_i).

The example above was recalculated with the improved AHP method. The results are listed in Table 8.

The ranking result of each plan is $A_3 > A_2 > A_4 > A_1$. If A_1 could not be implemented for some reason, we might recalculate the remaining three schemes. The result is shown in Table 9.

Table 8.Ranking of schemes

Index	C_1	C_2	C_3	Scheme Weight	Scheme Ranking
	0.191	0.705	0.104		
A^*	0.447	0.731	0.455	—	—
A_1	1.127303	0	0	0.215673	4
A_2	0.477158	0.110808	1	0.273252	**2**
A_3	0.507576	1	1	0.905791	**1**
A_4	0.127303	0.257846	0.2	0.226863	**3**

The result ranking of the remaining schemes is $A_3 > A_2 > A_4$. It is consistent with the results in Table 8. This demonstrates that the improved AHP method maintains the independence of the schemes, and makes the decision result more reasonable and scientific.

Table 9.Ranking of schemes

Index	C_1	C_2	C_3	Scheme Weight	Scheme Ranking
	0.191	0.705	0.104		
A^*	0.388	0.650	0.364	—	—
A_2	1.144	0.125	1.25	0.436	2
A_3	1.215	1.125	1.25	1.155	1
A_4	0.215	0.290	0.25	0.272	3

2.2. Fuzzy Sets and Fuzzy Numbers

Fuzzy set theory (Zadeh)[10] is the basis of fuzzy theory to define uncertain numbers. A fuzzy set $\tilde{A} = \{(x, \tilde{A}(x)) \mid x \in X\}$ can describe numbers' vague position. $\mu_{\tilde{A}}$ can determine the fuzzy set, and is named the membership function, which assigns to each number x ranging from zero to one. $\mu_{\tilde{A}}(x)$ is called the degree of membership function of x to A. The emergence of the concept of fuzzy set theory allows mathematical thoughts and methods to be able to deal with ambiguity. As the foundation of the fuzzy theory, fuzzy set theory has been widely employed in many areas in order to help decision-makers to deal with practical problem which need to address undetermined information.

$$\mu_{\tilde{A}} : U \rightarrow [0,1] \qquad \text{(iv)}$$

$$x| \rightarrow \mu_{\tilde{A}}(x) \in [0,1] \qquad \text{(v)}$$

In order to represent human semantics which is uncertain and vague, the concept of fuzzy numbers was proposed. A fuzzy number can be defined by a convex normalized fuzzy set. Generally, fuzzy numbers can be divided into triangular fuzzy numbers and trapezoidal fuzzy numbers. The difference between the two forms is that the triangle fuzzy number set is most likely to be represented by a single value when describing the uncertainty of the item, while the trapezoidal fuzzy number is most likely to be an interval form. The triangular fuzzy number (TFN) is an extreme form of the trapezoidal fuzzy number because a trapezoidal fuzzy number would become a TFN when the two most promising values are the same number. TFN is a widely applied membership function due to its perceptive attraction and high efficiency. $\tilde{A} = (l, m, u)$ is a fuzzy triangle number, which is shown in Figure 2. The parameters "l" and "u", respectively, are the lower and upper limits of the fuzzy numbers, and "m" is the most likely value. And the fuzzy triangle number's membership function is expressed as follows:

$$\mu_{\tilde{A}}(x) = \begin{cases} \dfrac{x-l}{m-l} & for\ l \le x \le m \\ \dfrac{u-x}{u-m} & for\ m \le x \le u \\ 0 & otherwise \end{cases} \qquad \text{(vi)}$$

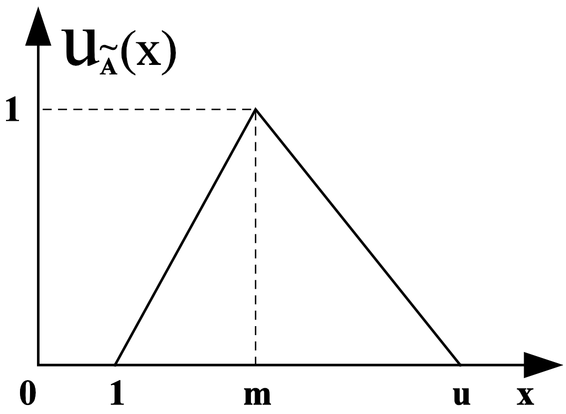

Figure 2.A triangular fuzzy number

The calculation method of two triangular fuzzy numbers A_1 and A_2 is as follows:

$\tilde{A}_1 = (l_1, m_1, u_1); \tilde{A}_2 = (l_2, m_2, u_2);\ for\ l_i, m_i, u_i > 0, i = 1, 2$.

$$\tilde{A}_1 \oplus \tilde{A}_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \qquad \text{(vii)}$$

$$\tilde{A}_1 \oplus \tilde{A}_2 \approx (l_1 l_2, m_1 m_2, u_1 u_2) \qquad \text{(viii)}$$

$$\tilde{A}_1 / \tilde{A}_2 \approx (l_1 / u_2, m_1 / m_2, u_1 / l_2) \qquad \text{(ix)}$$

$$(\lambda, \lambda, \lambda) \otimes (l_1, m_1, u_1) = (\lambda l_1, \lambda m_1, \lambda u_1),\ for\ \lambda > 0, \lambda \in R \qquad \text{(x)}$$

$$\tilde{A}_1^{-1} \approx (1/u_1, 1/m_1, 1/l_1) \qquad \text{(xi)}$$

2.3. The Extent Analysis Fuzzy AHP Method

Previous research[11] has summarized different fuzzy AHP methods, and each method has its own advantages and disadvantages. Among these methods, Chang's method[12] has been widely accepted for decision making in various areas, such as determining the best personnel for human resources department. Gungor's study[13] provided an explicit example for personnel selecting using FAHP which merely needs a less complex mathematic system. We follow its experience of building fuzzy AHP model for this study aims to solve similar problems except that we make some improvement in key steps.

According to the traditional AHP method of Chang, the steps can be described as follows:

Firstly, let $\tilde{A} = (\tilde{a}_{ij})_{n*m}$ be a fuzzy pairwise comparison matrix (FPCM), where $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$, then the value of fuzzy synthetic extent with respect to the i-th object is defined as:

$$S_i = \sum_{j=1}^{m} A_{ij} \otimes [\sum_{i=1}^{n}\sum_{j=1}^{m} A_{ij}]^{-1} \qquad \text{(xii)}$$

and

$$\sum_{j=1}^{m} A_{ij} = (\sum_{j=1}^{m} l_{ij}, \sum_{j=1}^{m} m_{ij}, \sum_{j=1}^{m} u_{ij}), i = 1, 2, ..., n \qquad \text{(xiii)}$$

$$\sum_{i=1}^{n}\sum_{j=1}^{m} A_{ij} = (\sum_{i=1}^{n}\sum_{j=1}^{m} l_{ij}, \sum_{i=1}^{n}\sum_{j=1}^{m} m_{ij}, \sum_{i=1}^{n}\sum_{j=1}^{m} u_{ij}) \qquad \text{(xiv)}$$

$$[\sum_{i=1}^{n}\sum_{j=1}^{m} A_{ij}]^{-1} = (\frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{m} l_{ij}}, \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{m} m_{ij}}, \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{m} u_{ij}}) \qquad \text{(xv)}$$

Secondly, compare variable S_i and S_j, and calculate the value of $S_j = (l_j, m_j, u_j) \geq S_i = (l_i, m_i, u_i)$. This can be equally expressed as follows:

$$V(S_j \geq S_i) = height(S_i \cap S_j) = \begin{cases} 1 & if \;\; m_j \geq m_i \\ 0 & if \;\; l_i \geq u_j \\ \dfrac{l-u}{(m-u)-(m-l)} & otherwise \end{cases} \qquad \text{(xvi)}$$

Third, as indicated in Figure 3, represents $V(S_j \geq S_i)$ for the case $m_j < l_i < u_j < m_i$, where d is the abscissa value of the highest intersection point between S_i and S_j. Values $V(S_j \geq S_i)$ and $V(S_i \geq S_j)$ are both necessary for comparing S_i and S_j. The minimum degree of possibility $d(i)$ of $V(S_j \geq S_i)\ for\ i, j = 1, 2, ..., k$ is calculated as follows.

$$\begin{aligned} & V(S \geq S_1, S_2, S_3, \ldots, S_k),\ for\ \ i = 1, 2, ..., k \\ & = V[(S \geq S_1) and (S \geq S_2) and ... (S \geq S_k)] = \min V(S \geq S_1),\ for\ \ i = 1, 2, ..., k \end{aligned} \qquad \text{(xvii)}$$

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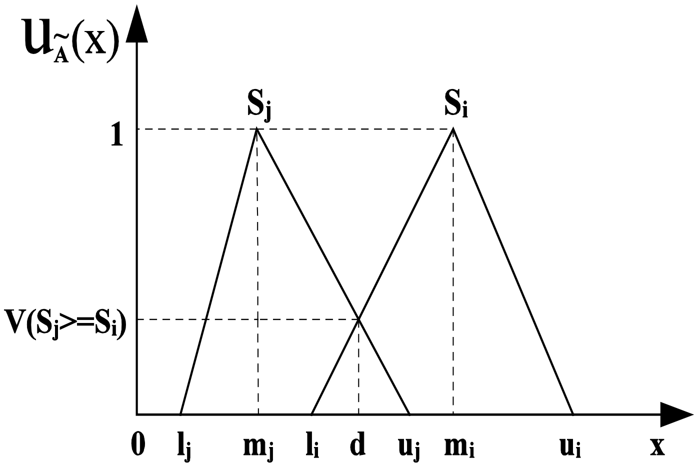

Figure 3. The intersection between S_i&S_j

Assume that $d'(A_i) = \min V(S \geq S_i)\ \ for\ i = 1,2,...k$, and then the weight vector can be defined as:

$$W' = (d'(A_1), d'(A_2), ..., d'(A_n))^T \qquad \text{(xviii)}$$

where $A_i (i = 1,2,3,...,n)$ comprises n elements.

Finally, the weight vectors are normalized as follows:

$$W = (\mathrm{W}_1, \mathrm{W}_2, \ldots, \mathrm{W}_n)^T \qquad \text{(xix)}$$

where $\mathrm{W}_1, \mathrm{W}_2, \ldots, \mathrm{W}_n$ are non-fuzzy numbers.

3. THE PROPOSED FRAMEWORK FOR DESIGNING PERFORMANCE EVALUATION SYSTEM

In order to assist decision-makers to obtain a scientific evaluation, it is necessary to establish a set of procedures for detailed implementation. These steps are composed of the following, including both subjective thoughts from experts and scientific support provided by improved FAHP.

3.1. Developing the Hierarchical Structure of the Evaluation Index System

While applying AHP to analyze decision problems, we must first model the problem as a hierarchy. According to the situation of the evaluation target, the evaluation index should be determined before we evaluate each indicator's weights. Since there exist many groups of options, each option should be classified and combined at levels from general to detailed to form typically a three-layer hierarchical model: the target layer, the criterion layer, and the scheme layer. The target layer merely includes one factor which is the overall goal. The criterion layer consists of a group of options or alternatives for reaching the goal. The scheme layer usually provides a certain number of options for decision making like ranking candidates. The above layers constitute the entire evaluation index system.

3.2. Determining the Linguistic Variables and Fuzzy Conversion Scale

In order to achieve a scientific decision, a committee of decision-makers needs to be established. And these decision-makers would be experts who have rich experience in the research area. After a thoughtful discussion, the group of decision-makers would determine the factors and sub-factors and give a considered and reasonable evaluation system. Each decision-maker needs to determine the relative weights of factors and sub-factors and finally obtain a comprehensive result.

The comparison between two factors can be obtained through a questionnaire with linguistic variables. Decision-makers would gain a reasonable decision through using linguistic variables. Each decision-maker in

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the foregoing committee would make pairwise comparisons of the significance or preference between each pair of factors. It is necessary to make $n(n-1)/2$ judgments. This approach can avoid the problem of unreasonable sequencing caused by the mistake of individual judgment. Therefore, making $n(n-1)/2$ comparisons can provide more information and conduct the final scientific positive fuzzy reciprocal comparison matrix. In this paper, linguistic variables are triangular fuzzy conversion scales and linguistic scales (TFNs), which can represent decision-makers' subjective pairwise comparisons, namely, "just equal", "equally important", "weakly more important", "strongly more important", "very strongly more important" and "absolutely more important". The triangular fuzzy conversion scales and linguistic scales were proposed by Kahraman[14] which can be seen in Table 10 and Figure 4.

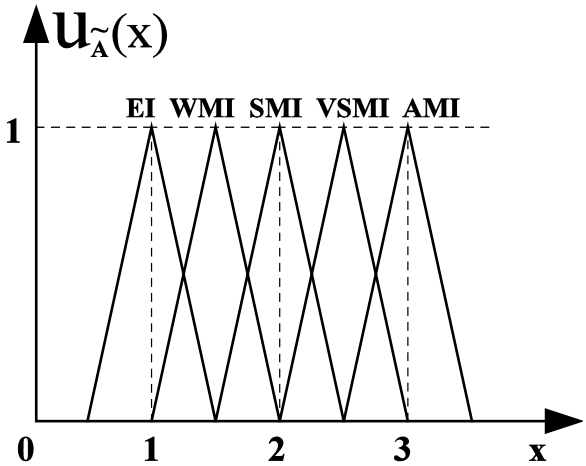

Figure 4. Linguistic scale for relative importance

Table 10.The triangular fuzzy conversion scales and linguistic scales

Linguistic scale for importance Triangular	Triangular fuzzy scale	Triangular fuzzy reciprocal scale
Just equal	(1, 1, 1)	(1, 1, 1)
Equally important (EI)	(1/2, 1, 3/2)	(2/3, 1, 2)
Weakly more important(WMI)	(1, 3/2, 2)	(1/2, 2/3, 1)
Strongly more important (SMI)	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)
Very strongly more important (VSMI)	(2, 5/2, 3)	(1/3, 2/5, 1/2)
Absolutely more important (AMI)	(5/2, 3, 7/2)	(2/7, 1/3, 2/5)

3.3. Establishing Comparison Matrices

The triangular fuzzy numbers can represent the relative preference between factor i and j, which is demonstrated as $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$. For example, if the decision-maker considers that factor i is very strongly more important than factor j, he/she can set $\tilde{a}_{ij} = (2, 5/2, 3)$ as defined in Table 10. Following the idea of traditional AHP, the comparison matrix $\tilde{A} = \{\tilde{a}_{ij}\}$ can be established as:

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$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & \dots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \dots & \tilde{a}_{2n} \\ \dots & \dots & \dots & \dots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \dots & 1 \end{bmatrix} = \begin{bmatrix} 1 & \tilde{a}_{12} & \dots & \tilde{a}_{1n} \\ 1/\tilde{a}_{12} & 1 & \dots & \tilde{a}_{2n} \\ \dots & \dots & \dots & \dots \\ 1/\tilde{a}_{1n} & 1/\tilde{a}_{2n} & ?.. & 1 \end{bmatrix} \quad (xx)$$

3.4.Calculating the Consistency Ratio of Comparison Matrix

In previous studies, Saaty[1] constructed a method to analyze the consistency of the pairwise comparison so that the final decision's effectiveness can be guaranteed. Before using this index to confirm the consistency of the evaluation, the fuzzy comparison matrices need to be defuzzified into crisp matrices. In this paper, we applied Chang's[5] method, which can express the extent of fuzzy clearly, to convert those fuzzy triangular numbers. According to this method, $\tilde{a}_{ij} = (l_{ij}, m_{ij}, u_{ij})$ can be defuzzified as follows:

$$(a_{ij}^{\alpha})^{\lambda} = \left[\lambda \cdot l_{ij}^{\alpha} + (1-\lambda) u_{ij}^{\alpha}\right], 0 \le \lambda \le 1, 0 \le \alpha \le 1 \quad (xxi)$$

$$l_{ij}^{\alpha} = (m_{ij} - l_{ij}) \times \alpha + l_{ij} \quad (xxii)$$

$$u_{ij}^{\alpha} = u_{ij} - (u_{ij} - m_{ij}) \times \alpha \quad (xxiii)$$

In the foregoing formula, α represents the preference and λ represents the risk tolerance. It is worth mentioning that α can demonstrate whether the condition is stable or fluctuating, and α 's range is between 0 and 1. The decision-making environment would be the most stable while α =1, while the degree of uncertainty would be the highest if α =0. λ would represent the extent of decision-makers' attitude and it is any value from 0 to 1. The decision-maker's attitude would be passive if λ =1, and its attitude would become more optimistic with the decreasing λ . What' more, l_{ij}^{α} and u_{ij}^{α} indicate the left-end and the right-end value of α -cut respectively.

After all numbers in the comparison matrix are transformed from triangular fuzzy numbers to crisp numbers, the comparison matrix is now demonstrated as follows:

$$[(A^{\alpha})^{\lambda}] = [(a_{ij})^{\lambda}] = \begin{bmatrix} 1 & (a_{12}^{a})^{\lambda} & \dots & (a_{1n}^{a})^{\lambda} \\ (a_{21}^{a})^{\lambda} & 1 & \dots & (a_{2n}^{a})^{\lambda} \\ \dots & \dots & \dots & \dots \\ (a_{n1}^{a})^{\lambda} & (a_{n2}^{a})^{\lambda} & \dots & 1 \end{bmatrix} \quad (xxiv)$$

If the matrix A is a consistent matrix, and its maximum characteristic root $\lambda_{\max}$ must be equal to n. When A is inconsistent, $\lambda_{\max}$ must be greater than n, and the larger the error, the larger the value of $\lambda_{\max}$ -n. Therefore, we can use whether $\lambda_{\max}$ is equal to n to check whether the matrix A is consistent.

The steps for the consistency check of the comparison matrix are as follows:

1. Calculate the consistency index CI:

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (xxv)$$

2. Find the corresponding average random consistency index RI. [15] For n=1,…,9, the value of RI is given in Table 11.

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Impact Factor: 5.164
CODEN: IJESS7

Table 11.The different value of RI with different n

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

The value of RI is obtained in this way. Construct 500 sample matrices randomly: random numbers are drawn from 1-9 and its inverse, and use these random numbers to construct a positive and reciprocal matrix. Finally, gain the average of the largest characteristic roots $\lambda_{\max}^{'}$ and define RI:

$$RI = \frac{\lambda_{\max}^{'} - n}{n-1} \tag{xxvi}$$

3. Calculate The Consistency Ratio CR:

$$\mathrm{CR} = \frac{CI}{RI(n)} \tag{xxvii}$$

When CR is less than 0.10, the consistency of the comparison matrix is considered to be acceptable, otherwise the comparison matrix should be corrected.

3.5. Establishing the Representative Matrix of the Whole Committee

Each decision-maker would have their comparison matrix. To obtain a common comparison, which can represent all decision-makers' comparison matrix, aggregation is necessary. Remarkably, the concepts and theories utilized in conventional AHP can also be applied in the fuzzy AHP. In the conventional AHP, there are two methods to aggregate the individual preference into a group preference, namely, aggregation of individual judgments (AIJ) and aggregation of individual priorities (AIP)[16].

According to the AIJ method, the group comparison matrix is converted from the individual comparison matrices directly. Specifically, the whole final comparison matrix would be regarded as the comparison matrix of a "new individual". On the contrary, in AIP theory, the factors' significance of decision-makers in the group would be analyzed separately. This means that the individual preference would be analyzed before we gain the group preference. Another difference is that AIJ usually applies geometric mean operations, whereas, AIP normally employs arithmetic mean operations. As the application of AHP often utilized geometric mean operations, in this research, AIJ is employed for aggregating group decisions.

The group would include K decision-makers, each of them would compare pairs of factors, and finally gain a set of K matrices, $\tilde{A}_k = \{\tilde{a}_{ijk}\}$. $\tilde{a}_{ijk} = (l_{ijk}, m_{ijk}, u_{ijk})$ can denote the degree of significance of factor I to factor j. By using the following Eq.28, the triangular fuzzy numbers in the group judgment matrix can be calculated[11].

$$l_{ij} = \min_{k=1,2,\ldots,K}(l_{ijk})$$
$$m_{ij} = \sqrt[K]{\prod_{k=1}^{K} m_{ijk}} \tag{xxviii}$$
$$u_{ij} = \max_{k=1,2,\ldots,K}(u_{ijk})$$

Analyze the factors and sub-factors' weights in group decision matrices through using the extent analysis fuzzy AHP method. Therefore, finally gain the best strategy by qualitative and quantitative methods.

4. CONSTRUCTING THE TEACHING QUALITY EVALUATION SYSTEM

4.1. Construct the Teaching Performance Hierarchical Structure

Establishing a blending teaching quality evaluation system is required to improve the quality of teaching and learning. The teaching quality evaluation standard has the functions of guidance, diagnosis improvement, feedback and motivation. In order to make the evaluation results fair and equitable, the data of the evaluation of teaching quality would from students, colleagues and teachers themselves. However, because there are too many factors that affect the quality of teaching, and each factor has a different degree of influence, it is difficult to design a scientific evaluation system.

In previous studies, Yang[17] has proposed a reasonable evaluation system. The teaching quality evaluation system makes the attributes and characteristics of the impact factors concrete, and gives the corresponding weights to the first-level elements of the index system. The literature designs the teaching quality evaluation indicators based on the document "Opinions on Strengthening the Construction and Application of Online Open Courses in Higher Education". In addition, the innovation of this article is the introduction of the official teaching evaluation data of the Academic Affairs Office into the evaluation index system. The teaching evaluation data comes from the students of the whole school. The data has high credibility and can improve the reliability of the evaluation system. The hierarchical structure of the teaching performance evaluation index system can be seen in Table 12. The first-level factors include "Teacher Performance", "Student Performance" and "MOOC Course". The indicators in Table 12 follow the principles of comprehensive integrity and relative independence, that is $\sum_{i=1}^{3} C_{1i} = C_1, C_{1i} \bigcap C_{1j} (i \neq j) = \varnothing$.

Table 12. The hierarchical structure of teaching performance

First-level Factors	Secondary Factors	Secondary indicators explanation
Teacher Performance	Content of courses	The class content is comprehensive, and all key and difficult points are involved
	Teacher behavior	Answer students' questions patiently at any time and the class arrangement is proper
	Teaching quality evaluation	The data of teaching quality evaluation from Teaching Management System
Student Performance	Students' enthusiasm	Students participate in class actively, focus on teamwork, and ask questions voluntarily
	Learning achievement	Students' teamwork ability and innovation ability are enhanced during the learning process, and professional knowledge is enhanced
MOOC Course	MOOC Course	A proper combination of technology and theory. Complete content, no scientific and politic errors. Proficiency in writing and oral language

4.2. Consider the Weights of Factors

When designing the teaching evaluation system, the weights of each first-level factors and secondary factors need to be determined. In order to obtain an objective and reasonable evaluation system, a committee of 3 education experts was constructed. Expert evaluation means that the school will hire a group of experts with rich teaching experience to form teaching supervision organizations to listen to courses. The proposal of a classroom quality evaluation system with expert evaluation has guaranteed the comprehensiveness of teaching quality evaluation. This kind of evaluation method is helpful for the Academic Affair Office to control the teaching quality of the whole school, and it is also helpful for teachers to improve the teaching quality.

Experts in the group need to finish a questionnaire about factors' weights. In the questionnaire, everyone will give the relative importance of one factor relative to another factor, and a comparison matrix for each decision-maker would be formed from the results of the questionnaire. Through applying Eq.28, the comparison matrix of the group is finally calculated. As we can see in Table 13, the representative comparison matrix of the group can demonstrate pairwise comparisons of the first-level factors.

Table 13.Comparison matrix of the factors

	C_1	C_2	C_3

C_1	(1,1,1)	(1,1.817,2.5)	(1.5, 2.154,3)
C_2	(0.4,0.550,1)	(1,1,1)	(1,1.651,2.5)
C_3	(0.333,0.464,0.667)	(0.4,0.608,1)	(1,1,1)

The next step is to calculate the consistency of the comparison matrix. According to the previous theory, decision-makers' preference for factors would be affected by the degree of environment's uncertainty. $\alpha = 0.5$ represents that the decision-making environment is stable, and $\lambda = 0.5$ demonstrates that the decision-makers' attitude is fair. When $\alpha = 0.5$ and $\lambda = 0.5$, applying Eq.21, the triangular number $\tilde{a}_{13}$ in pairwise comparison matrix can be defuzzified as follows:

$$l_{13}^{0.5} = (1.957 - 1) \times 0.5 + 1 = 1.4785$$

$$u_{13}^{0.5} = 3 - (3 - 1.957) \times 0.5 = 2.4785$$

$$(a_{13}^{0.5})^{0.5} = 0.5 \times 1.4785 + (1 - 0.5) \times 2.4785 = 1.9785$$

By employing Eq.21, all triangular numbers in Table 13 can be transferred into crisp numbers in Table 14. According to Eq.25-27, the Consistency Ratio of the crisp comparison matrix is 0.0964, which demonstrates that the comparison matrix is acceptable.

Table 14.Crisp comparison matrix of the factors

	C_1	C_2	C_3
C_1	1	1.784	2.202
C_2	0.625	1	1.701
C_3	0.482	0.653	1

Similarly, the second-level indicators that affect teacher performance and student performance are compared in pairs on the extent of their influence on the first-level index factors, which is shown in Table 15 and Table 16. Using the important criteria in Table 10 can reduce the bias when conducting the comparison. By making the same defuzzify calculation and consistency test as Table 14, the results show that both tables' consistency ratios are smaller than 0.1, so that both matrices are consistent. The obtained weight set can reflect the importance of each indicator, and the weight distribution is reasonable.

Table 15.Comparison matrix of the secondary factors within "Teacher Performance" (C_1)

	C_{11}	C_{12}	C_{13}
C_{11}	(1,1,1)	(1,1.5,2)	(1.5,2.321,3)
C_{12}	(0.5,0.667,1)	(1,1,1)	(1,1.651,2.5)
C_{13}	(0.333,0.431,0.667)	(0.4,0.606,1)	(1,1,1)

Table 16.Comparison matrix of the secondary factors within "Student Performance" (C_2)

	C_{21}	C_{22}
C_{21}	(1,1,1)	(1,1.957,3)
C_{22}	(0.4,0.511,1)	(1,1,1)

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

Then, according to the fuzzy AHP method, hierarchical single ordering and hierarchical total ordering are performed to determine the evaluation factor weights. Using the Eq.16-19, calculate the weights of factors as follows:

Take the factors in Table 13 as an example, we gained the TFN values of the three output indicators as follows:

$$S_1 = (3.5, 4.972, 6.5) \otimes (\frac{1}{13.667}, \frac{1}{10.243}, \frac{1}{7.633}) = (0.256, 0.485, 0.852)$$

$$S_2 = (2.4, 3.201, 4.5) \otimes (\frac{1}{13.667}, \frac{1}{10.243}, \frac{1}{7.633}) = (0.176, 0.313, 0.590)$$

$$S_3 = (1.733, 2.070, 2.667) \otimes (\frac{1}{13.667}, \frac{1}{10.243}, \frac{1}{7.633}) = (0.127, 0.202, 0.349)$$

Based on Eq.16, the values of S_i and S_j are compared, and the degree of $S_i = (l_i, m_i, u_i) \geq S_j = (l_j, m_j, u_j)$ is calculated. The values of $V(S_i \geq S_j)$ can be expressed in Table 17:

Table 17.Values of V($S_i \geq S_j$)

$V(S_1 \geq S_j)$	Value	$V(S_2 \geq S_j)$	Value	$V(S_3 \geq S_j)$	Value
$V(S_1 \geq S_2)$	1	$V(S_2 \geq S_1)$	0.659	$V(S_3 \geq S_1)$	0.248
$V(S_1 \geq S_3)$	1	$V(S_2 \geq S_3)$	1	$V(S_3 \geq S_2)$	0.611

Thenceforth, the minimum degree of possibility $d'(i)$ of $V(S_i \geq S_j)$ for $i, j = 1, 2, 3$ can be calculated through Eq.17.

$$d'(1) = \min V(S_1 \geq S_2, S_3) = 1$$

$$d'(2) = \min V(S_2 \geq S_1, S_3) = 0.659$$

$$d'(3) = \min V(S_3 \geq S_1, S_2) = 0.248$$

Thereafter, the weight vector can be determined by using Eq.18.

$$W' = (1, 0.659, 0.248)^T$$

Then the weight vectors are normalized using Eq.19, and the relative weights of the three first-level factors are gained as follows. It is worth mention that W is a non-fuzzy matrix.

$$W = (0.525, 0.345, 0.130)^T$$

The analyzed results demonstrate that "teacher performance" (C_1) is the most significant in the first-level factors, followed by "student performance" (C_2). After a similar calculation, the weights of the second-level factors can be displayed as follows:

The weight vector of "Teacher Performance" (C_1) was calculated as $W_1 = (0.525, 0.358, 0.118)^T$

The weight vector of "Student Performance" (C_2) was calculated as $W_2 = (0.694, 0.306)^T$

ISSN: 2277-9655
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Since "MOOC Course" (C_3) has only one sub-factor, it is not weighted. In addition, the above matrix will constitute the evaluation matrix for applying fuzzy AHP in evaluating teaching performance.

Finally, the weights of the second-level factors and their corresponding first-level factors are multiplied to obtain the weights of each factor, as shown in the Table 18.

Table 18.the final weights of factors

	C_1 0.525			C_2 0.345		C_3 0.130
weight	C_{11} 0.276	C_{12} 0.188	C_{13} 0.062	C_{21} 0.239	C_{22} 0.106	C_3 0.130

5. APPLICATION OF FUZZY AHP IN TEACHING PERFORMANCE EVALUATION

The indicators of various levels of teaching quality evaluation have been determined previously, and the weight coefficients of the indicators of various levels have been obtained by employing fuzzy AHP. In this chapter, we will use the established teaching quality evaluation system and FAHP to evaluate the teaching quality of specific courses.

Fuzzy AHP is a method to specify and quantify people's thinking processes and subjective judgments, which can greatly reduce uncertain influence. The biggest problem of the AHP is evaluation indexes' consistency are difficult to be guaranteed. In this case, the improved fuzzy AHP, which divides the weight by the range, will address this problem well. In this paper, we use a two-layer fuzzy AHP model as a tool for evaluating teaching quality.

Existing colleges would evaluate teachers' teaching every semester, so that teachers can improve their teaching quality. And an increasing number of teachers would introduce MOOCs into their courses to enriching course content. However, at present, there is rarely an evaluation system for online and offline mixed teaching courses. Therefore, in this article, we will use the above-mentioned teaching evaluation system established for mixed teaching to estimate the teaching performance in college.

This article takes five blending teaching courses in a university as the evaluation target. These five mixed teaching courses are: ERP simulation exercise, python data analysis, college English listening and speaking, international finance and fundamental accounting. And three experts who are familiar with the assessment of teaching quality, would use the foregoing teaching quality evaluation index system to compare each pair of courses, and finally, get the course with the highest quality.

The specific teaching quality assessment process is as follows:

1) Constructing a Pairwise Comparison Matrix for Five Courses

Constructing a judgment matrix is a key step in the FAHP method. Each expert in the group compares the performance of the five courses on each of the secondary indicators, and form three judgment matrixes. The source of these data is generally given by education experts who independently complete the questionnaire. The elements in the judgment matrix refer to the triangular fuzzy number in Table 10, which can be quantified.

By using the Eq.28, aggregate the three expert judgment matrices of sub-factors and get comparison matrixes for second-level factors, some of them can be seen in Table 19 and Table 20.

Most of those matrixes are fuzzy matrix, while the data in Table 21 is definite. This matric represents the data of "Teaching quality evaluation" in "Teacher Performance". These numbers come from the teaching quality evaluation database of TMS. The university requires students to evaluate the teacher's curriculum in the academic system at the end of each semester. So the matrix is not fuzzy and the data is real and reliable.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

Table 19 Comparison matrix of "Content of courses"(C_{11}) from expert evaluation

	A_1	A_2	A_3	A_4	A_5
A_1	(1,1,1)	(0.5,1.310,2)	(2,1,1.651)	(1.5,2,2.5)	(1.5,2.154,3)
A_2	(0.5,0.7631,2)	(1,1,1)	(1,0.5,1.310)	(1,1.651,2.5)	(1,1.817,2.5)
A_3	(0.4,0.606,1)	(0.5,0.763,2)	(1,1,1)	(0.5,1.310,2)	(0.5,1.310,2)
A_4	(0.4,0.5,0.667)	(0.4,0.606,1)	(1,0.5,0.763)	(1,1,1)	(0.5,1.447,2)
A_5	(0.333,0.464,0.667)	(0.4,0.550,1)	(1,0.5,0.763)	(0.5,0.874,2)	(1,1,1)

Table 20Comparison matrix of "Teacher behavior"(C_{12}) from expert evaluation

	A_1	A_2	A_3	A_4	A_5
A_1	(1,1,1)	(0.5,0.7631,1.5)	(0.5,1,2)	(1,1.651,2.5)	(1,1.651,2.5)
A_2	(0.667,1.310,2)	(1,1,1)	(0.5,1.260,2.5)	(1,1.957,3)	(1,1.957,3)
A_3	(0.5,1,2)	(0.4,0.794,2)	(1,1,1)	(1,1.651,2.5)	(1,1.651,2.5)
A_4	(0.4,0.606,1)	(0.333,0.511,1)	(0.4,0.606,1)	(1,1,1)	(0.5,1,1.5)
A_5	(0.4,0.606,1)	(0.333,0.511,1)	(0.4,0.606,1)	(0.667,1,2)	(1,1,1)

Table 21.Comparison matrix of "Teaching quality evaluation"(C_{13}) from expert evaluation

	A_1	A_2	A_3	A_4	A_5
A_1	1	1.079	1.032	1.116	1.143
A_2	0.927	1	0.957	1.035	1.060
A_3	0.969	1.045	1	1.081	1.107
A_4	0.896	0.966	0.925	1	1.024
A_5	0.875	0.944	0.903	0.977	1

2) Calculate the weight of each course in each factor

Use Eq.21 to defuzzy the comparison matrices for six second-level factors, and then calculate the CR value of each matrix. It was found that the CR values of the above tables were 0.0812, 0.0747, 0.062, 0.973and 0.872, all less than 0.1. This shows that the foregoing tables are credible. Then, use Eq.16-19 to calculate the weight of each course in each factor. Then, the weight vectors are normalized by using Eq.19 and gain the relative weights of the five courses, which are shown in Table 22.

Among them, it is worth mentioning that the data of C_{13} comes from the teaching evaluation system of TMS. Therefore, the C_{13} data is not ambiguous. Surprisingly, after we weighted the judgment matrix, we found that the weight of each course in C_{13} is the ratio of its teaching evaluation scores. Then, the weight vectors are normalized by using Eq.19 and gain the relative weights of the five courses, which are shown in Table 22.

Table 22.The relative weights of the five courses

	C_{11}	C_{12}	C_{13}	C_{21}	C_{22}	C_3
A_1	0.261	0.221	0.214	0.286	0.218	0.204
A_2	0.230	0.247	0.199	0.164	0.186	0.138
A_3	0.192	0.223	0.208	0.129	0.152	0.184
A_4	0.161	0.151	0.192	0.210	0.270	0.249
A_5	0.156	0.158	0.188	0.210	0.174	0.225

3) Sorting Courses with Improved FAHP

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

The above-mentioned improved AHP method is used to calculate the weight of the schemes. According to Eq.2 and 3, the total utility $U(A_i)$ of each scheme is calculated and the schemes are rearranged based on the value of $U(A_i)$. The calculation results are shown in the Table 23.

Table 23. Ranking of various schemes

Index	C_{11}	C_{12}	C_{13}	C_{21}	C_{22}	C_3	U (A_i)	Scheme ranking
	0.276	0.188	0.062	0.239	0.106	0.130		
A^*	0.105	0.097	0.027	0.157	0.118	0.111	—	—
A_1	0.261	0.221	0.214	0.286	0.218	0.204	2.480	1
A_2	0.230	0.247	0.199	0.164	0.186	0.138	2.122	2
A_3	0.192	0.223	0.208	0.129	0.152	0.184	1.964	4
A_4	0.161	0.151	0.193	0.210	0.270	0.249	2.013	3
A_5	0.156	0.158	0.188	0.210	0.174	0.225	1.888	5

The results show that the comprehensive ranking of the five courses is: $A_1 > A_2 > A_4 > A_3 > A_5$. The evaluation results are mostly consistent with the results of the "Internet +" classroom teaching competition held by this college. This proves that the teaching quality evaluation system proposed in this paper is credible, and the improved AHP method can maintain the independence between various programs, making the decision-making results more professional.

In the teaching quality evaluation system which is established in this paper, teacher performance is the most important factor in the first layer. In the second layer of factors, course content and teacher behavior are the most important. We interviewed education department heads and faculty about the evaluation system and the results of the evaluation. They all agree that the results obtained by the evaluation system are more transparent and objective than the traditional one. The innovative teaching quality assessment process in this article can help teachers to realize how they can do to improve their teaching performance. Therefore, utilizing this method can promote the quality of teaching in universities.

6. CONCLUSION

With the development of modern technology, the MOOC teaching model is gradually integrated into the university teaching process, which has also brought new opportunities and challenges to teachers. At present, most evaluation systems are designed to measure the teaching quality of offline courses, and do not consider the influence of MOOC. Establishing a teaching quality evaluation system for online and offline mixed teaching courses is of great importance in updating teaching concepts and standardizing the teaching process.

In this article, the teaching quality evaluation system is innovated, and the requirements of offline teaching and the standards of online teaching are integrated into the evaluation system. This makes the teaching quality evaluation system become more reasonable. In addition, this paper combines the fuzzy theory and the AHP method, combining qualitative evaluation and quantitative evaluation. Applying fuzzy AHP in teaching performance evaluation can not only improve the overall learning effect of the course, but also reflect the teachers' achievements on each assessment factor. The teaching evaluation results can help teachers to improve their teaching process.

Another advantage of this method is the introduction of a fuzzy analytic hierarchy process to determine the weight of factors in the evaluation index system. Due to the ambiguity of human judgments, FAHP can digitize human's subjective judgments, making the weights in the indicator system more objective and reasonable. Similarly, FAHP is also employed in the evaluating process to calculate the result ranking of courses. This

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

means that experts need to describe the relative importance between courses with triangular fuzzy numbers, which greatly improves the accuracy of assessment results.

In addition, in the final selection process, this paper improved the AHP method. Divide the weight of the scheme by the value of the ideal scheme to represent the relative weight of the scheme. This improved scheme makes each scheme relatively independent, making the final ranking of the scheme more effective and more scientific.

The application in this article shows the value and applicability of the innovative evaluation system in teaching quality assessment. This FAHP method can provide an effective, scientific and objective method to assess the quality of teaching in higher education. In addition, this study proposes a decision-making system based on the FAHP method. Applying this system has both theoretical and practical value. Therefore it can also be utilized in the problem of managing employees or choosing government programs.

7. ACKNOWLEDGEMENTS

This work was partially supported by Chinese National Funding of Social Sciences (17BGL047) and Teaching Reform Research Project of Zhejiang Higher Education in the 13th Five-Year Plan (jg20180201).

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ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

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