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The Fuzzy Hierarchical Evaluation System in History Teaching

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ABSTRACT: *Evaluation of history teaching is a fundamental part of history teaching, which refers to the project in which history teachers use scientific methods to judge the value of the history teaching process, the effectiveness of the teaching, and various factors affecting teaching according to classroom standards. This paper proposes a framework system for history teaching evaluation based on a fuzzy analytic hierarchy process. Specifically, a history teaching index system is established after determining the factors and subfactors. In the index system, the fuzzy analytical hierarchy process estimates the weights of factors and subfactors, and the fuzzy analytic hierarchy process in group decision-making in history teaching can promote decision-makers to reach a consensus. Based on systematic evaluation of history teaching, we make use of the fuzzy comprehensive evaluation method to evaluate the teaching effect of history teaching. The final experimental results verify that the evaluation results are more scientific, accurate, and objective, and further, this work can be used as an auxiliary tool for history teaching managers to improve the quality of history education*

KEYWORDS *-fuzzy analytic hierarchy process, history teaching evaluation*

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I. INTRODUCTION

It is imperative to reform the history curriculum in ordinary middle school schools. Motivating the students' aggressiveness in learning history and giving them full room for exercise in the classroom is a crucial issue, and it is also a vital issue that every teacher strives to pursue. To improve their competitiveness in history education, it is necessary to provide the best teaching evaluation concepts to serve social needs. Good teaching service evaluation can improve students' satisfaction with history study and attract more prospective students. The best service to society can only be provided by a commitment to continuously improving the quality of history teaching [1]. Many history teachings are committed to continuous improvement, so it is imperative to evaluate the level of teaching they provide. Therefore, high-quality history teaching should always be one of the primary goals of educational institutions, so it is necessary to evaluate the quality of history teaching. The purpose of assessing the quality of history teaching is to cultivate the professional history quality of each teacher, encourage self-improvement, and maintain achievement. Assessing history teaching performance is not easy because it involves imprecise, ambiguous, and uncertain human decision-making. Therefore, using scientific methods to evaluate the quality of history teaching comprehensively and effectively plays a vital role in determining the quality of history teaching. In recent years, researchers have made relevant achievements in assessing teaching quality. [2] proposed a teaching performance evaluation method based on the Analytic Hierarchy Process (AHP). The evaluation results can more objectively reflect the teaching quality. [3] combined fuzzy and neural networks to evaluate teaching quality. They used historical data as a standard metric to train a network of neurons. This method is a good application of fuzzy theory in the evaluation of teaching performance. Lumley et al. [4] proposed a method for teaching performance evaluation using abnormal data using fuzzy methods. Their methods provide an accurate assessment of teaching performance, and the studies all provide a good application of mathematical models in performance assessment. However, these studies did not take enough consideration to the design of the scientific evaluation index system. In addition to the above studies focus, other related studies primarily on the strategies and theories of teaching performance evaluation, and few studies focus on the quantitative analysis of the evaluation index system.

Since the key to the evaluation process is the design of the evaluation index system, the research focuses on establishing a teaching performance evaluation index system with reasonable and objective factor weights. Determining the weight of a factor is relevant for multi-criteria decision-making problems, where decision-makers are often more confident in giving linguistic variables rather than expressing their judgments in numerical form. Therefore, fuzzy set theory is useful for dealing with imprecise and uncertain data. AHP, developed by Berk [5], is a practical decision-making method.

As an extension of the analytic hierarchy process, the fuzzy analytic hierarchy process can solve the problem of hierarchical fuzzy decision making. Various researchers have widely used fuzzy AHP to solve different decision-making problems. Mikhailov and Tsvetinov [6] used fuzzy AHP to deal with the uncertainty and imprecision of the service evaluation process. Chen et al. [7] proposed a fuzzy AHP-based personnel selection system that evaluates the best and most suitable personnel for handling qualitative and quantitative criteria ratings. Moayeri et al. [8] used fuzzy AHP to evaluate the weight of each criterion in S&T HR. Fuzzy AHP has also been used with other techniques to solve real-life decision-making problems. A combination of blur AHP and blur Kano is proposed to optimize the product variety of smart cameras [9].

In this study, when products have functional characteristics, fuzzy AHP can effectively extract customers' preferences for core attributes related to multi-level specifications. Moayeri, M et al. [10] utilize fuzzy AHP and fuzzy TOPSIS to assess construction projects and their overall risks under incomplete and uncertain conditions. In their work, fuzzy AHP was used to create favorable weights for fuzzy linguistic variables of the overall risk of construction projects. These studies reveal the high applicability of fuzzy AHP in solving practical problems. Therefore, fuzzy AHP is suitable for determining the weights in the performance evaluation index system. In our research, in order to evaluate teaching performance, a new framework based on fuzzy AHP and fuzzy comprehensive evaluation method is proposed. Specifically, it is used to obtain the factor and subfactor weights of the teaching performance evaluation index system. On the basis of this system, fuzzy comprehensive evaluation can be used to evaluate teaching performance.

The rest of this paper is organized as follows: Section 2 introduces fuzzy methods and some related concepts. Section 3 establishes the fuzzy evaluation system of the history teaching evaluation index. Section 4 presents the application of the evaluation index system based on the comprehensive evaluation method; finally, we conclude this paper in Section 5.

II. FUZZY SETS AND FUZZY NUMBERS

Fuzzy set theory [11] was first introduced to deal with uncertainty due to imprecision or ambiguity. a fuzzy set $\tilde{A} = \{x, \mu_{\tilde{A}}(x) | x \in X\}$ is a set of ordered pairs, X is a subset of real numbers R, where $\mu_{\tilde{A}}(x)$ is called the membership function, which is the membership level of each object x. This paper employs triangular fuzzy numbers to deal with the ambiguity of decisions related to the performance level of alternative choices for each criterion. A triangular fuzzy number, denoted $\tilde{A} = (a, b, c)$ has the following membership functions:

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{x-a}{b-a}, fora < x < b \\ \frac{c-x}{c-b}, forb < x < c \\ 0, \quad otherwise \end{cases} \tag{1}$$

A triangular fuzzy number is shown in Figure 1. The parameter "b" is the most promising value. Parameters "a" and "c" are the minimum and maximum possible values, respectively; they limit the possible evaluation field. When a = b = c, triangular fuzzy numbers become non-fuzzy numbers. Triples (a , b , c) can be used to describe fuzzy events.

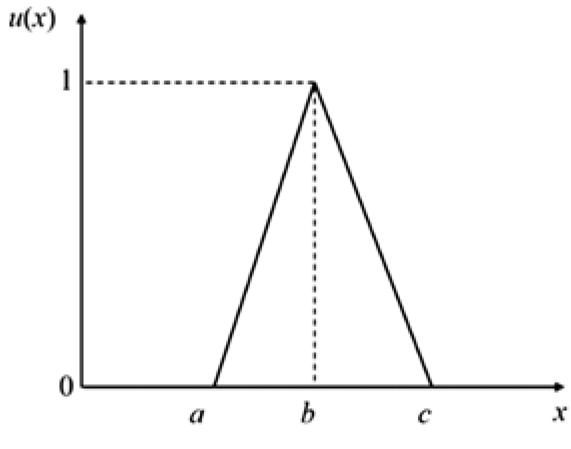

Fig1：A triangular fuzzy number

Consider two $\widetilde{A_1} = (a_1, b_1, c_1)$ and $\widetilde{A_2} = (a_2, b_2, c_2)$ algorithms for two triangular fuzzy numbers:

$$\widetilde{A_1} \oplus \widetilde{A_2} = (a_1 + a_2, b_1 + b_2, c_1 + c_2)$$
$$\widetilde{A_1} \otimes \widetilde{A_2} = (a_1 a_2, b_1 b_2, c_1 c_2)$$
$$\widetilde{A_1} / \widetilde{A_2} = (a_1 / a_2, b_1 / b_2, c_1 / c_2) \tag{2}$$

$$1/\widetilde{A_2} = (1/a_2, 1/\mathrm{b}_2,\ 1/\mathrm{c}_2)$$

In this study, we adopt this approach to derive factor and sub-factor weights from expert opinions for pairwise comparisons. Let $\tilde{A} = (\widetilde{a_{ij}})_{n\times m}$ be a fuzzy pairwise comparison matrix, where $\widetilde{a_{ij}} = (a_{ij}, b_{ij}, c_{ij})$.

The steps of the specific method can be described as follows:

Initially, the value of the fuzzy synthesis range for the i-th object is defined as: $S_i = (a_i, b_i, c_i)$, values and calculate the likelihood that $S_j = (a_j, b_j, c_j) \geq S_i = (a_i, b_i, c_i)$ This can be equivalently expressed as follows:

$$V(S_j \geq S_i) = \begin{cases} 1, & for b_j \geq b_i \\ 0, & for a_i \geq c_j \\ \frac{a_i - c_j}{(b_j - c_j) - (b_i - a_j)}, & otherwise \end{cases} \quad (3)$$

Calculate $V(S_j \geq S_i)$ and $V(S_i \geq S_j)$ to compare S_i and S_j. For i,j =1, 2, 3 ...,k, $V(S_j \geq$ Si of minimum likelihood d (i) Calculated as follows

$$V(S \geq S_1, S_2, \ldots, S_k) for i = 1,2,3 \ldots k$$

$$V[(S \geq S_1)\ and\ (S \geq S_2), \ldots, and\ (S \geq S_k)] \quad (4)$$

$$= \min V(S \geq S_i)\ for i = 1,2,3 \ldots k$$

III. FUZZY EVALUATION SYSTEM OF HISTORY TEACHING EVALUATION INDEX

According to the established evaluation scale and weight, evaluate the evaluation items at all levels, and obtain the membership degree matrix：

$$\tilde{A} = \begin{bmatrix} r_{11}^k r_{12}^k \ldots\ldots r_{1m}^k \\ r_{21}^k r_{22}^k \ldots\ldots r_{2m}^k \\ \ldots\ldots \\ r_{n1}^k r_{n2}^k \ldots\ldots r_{nm}^k \end{bmatrix} \quad (5)$$

where $r_{ij}^k = (a_{ij}, b_{ij}, c_{ij})$, r_{ij}^k is the k evaluation item of the k History Lesson. It is necessary to design the evaluation index system from different angles and levels to reveal the effect of history teaching accurately. However, developing teaching evaluation indicators is not an easy task [12] because many factors affect the teaching effect, and they are at different levels and have different relative importance weights. To obtain correct and objective evaluation results, the data sources used to assess teaching effectiveness are students, colleagues, and teachers themselves. Therefore, the index system used in the evaluation process should be able to get their opinion on the quality of history teaching. Several organizations have developed guidelines that provide criteria for performance effectiveness in history teaching [13].In this work, the hierarchical structure of the teaching effect evaluation index system [Fig. 2]. The selected factors and sub-factors are discussed and revised by administrators and experienced lecturers of educational institutions. Then implement the final hierarchy as shown. It consists of three elements: "classroom teaching," "student evaluation," and "expert evaluation," each of which is further divided into two or more sub-items. Figure 1 shows the index system:

Target layer　Criterion layer　Indicator layer

History Teaching Evaluation A
- classroom teaching
  - Teaching goal
  - teaching content
  - teaching content classroom reform consciousness
  - teaching strategy teaching organization
  - teaching media 体
  - status goal
- Student evaluation
  - Interaction situation
  - question attractiveness
  - teacher's responsible attitude
  - rich and effective
- Expert evaluation
  - teaching attitude
  - teaching ability
  - teaching effect

Fig.2 The index system

Based on the evaluation index system of historical teaching effect and the obtained factors and sub-factor weights, the fuzzy comprehensive evaluation method is used to evaluate the teaching performance. To illustrate the method, we take a case application as an example.

Fuzzy comprehensive evaluation is an application of fuzzy mathematics [14]. It uses fuzzy transformation and the principle of maximum membership degree to comprehensively evaluate all relevant factors. This is an effective evaluation method[15] for evaluating objects affected by various factors. We can use a one-layer model for objects affected by several factors. If the object is complex and the number of factors is large, we can use a model with two or more layers. This paper adopts a two-layer fuzzy comprehensive evaluation model as a tool for teaching performance evaluation. The application steps of fuzzy comprehensive evaluation can be described as follows:

Step 1: Establish an evaluation index system

According to the characteristics of the evaluation index system, the factors set in the evaluation relationship are: $U = \{u_1, u_2, \ldots, u_n\}$, Establish a history teaching effect evaluation system, and calculate the weights of factors and sub-factors.

Step 2: Determine the set

The set of evaluation comments is as follows: $V = \{v_1, v_2, \ldots, v_m\}$. In this paper, we use five scales to set evaluation reviews: V = {excellent, very good, good, fair, poor}. To quantify the metrics, we provide ratings for the corresponding review tables: $V =$ (100, 85, 70, 55, 40).

Step 3: Establish a single factor evaluation matrix R from U to V

Each factor μ_i(i ≤ n) should be evaluated as a single factor. Due to the different types of evaluation levels, the evaluation result of each factor is a fuzzy set of the evaluation set V, which can be written as a fuzzy vector $R_i = (r_{i1}^k r_{i2}^k \ldots\ldots\ r_{im}^k)$. The results of these evaluations satisfy the normalization condition, and the weights of the vectors sum up to 1. That is, for each i, there are: $r_{i1}^k + r_{i2}^k + \ \ldots\ldots + r_{im}^k = 1$ All single factor evaluations form a fuzzy relationship R from U to V:$R = (r_{ij}^k)_{n\times m}$ that is:

$$R = (r_{ij}^k)_{n\times m} = \begin{bmatrix} r_{11}^k r_{12}^k \ldots\ldots\ r_{1m}^k \\ r_{21}^k r_{22}^k \ldots\ldots\ r_{2m}^k \\ \ldots\ldots \\ r_{n1}^k r_{n2}^k \ldots\ldots\ r_{nm}^k \end{bmatrix} \tag{6}$$

r_{ij}^k Represents the membership rank of the factor μ_i for the comment v_j.

Step 4: Determine Factor Weights

Weight refers to the proportion of each evaluation factor in the evaluation index system on the basis of relative importance. If an element is given a weight, the weight distribution set W can be regarded as a fuzzy set of the set U. How to determine the weight of each factor is the core task of the evaluation system. In this paper, we use the fuzzy analytic hierarchy process to determine the weights of factors and sub-factors in the evaluation index system.

Step 5: Generate assessment results

The evaluation result can be obtained by multiplying the factor weight vector by the single factor evaluation matrix R:$\mathrm{B} = \mathrm{W} * \mathrm{R} = (\mathrm{b}_1, \mathrm{b}_2, \ldots, \mathrm{b}_\mathrm{m})$

Among them, B is the evaluation result based on all factors in the index system U. The k-th element b_k is the membership of the evaluation object with respect to the k-th element in the review set. The principle of maximum membership degree can draw the conclusion of a comprehensive evaluation.

IV. CASE APPLICATION

We take the history teaching of Shenzhen Junior High School as an example. Evaluate the effectiveness of history teaching by relevant teachers. The purpose of evaluating the effectiveness of history teaching is to provide information and feedback to the classroom to improve the quality of teaching. However, existing evaluation methods are mainly based on knowledge acquisition. This approach does not apply to lifelong education, nor does it deepen and expand educational reforms. Furthermore, assessment procedures are mostly formal and lack accuracy and objectivity. The inaccuracy of the evaluation work is due to the lack of a teaching standard and a method for evaluating the performance of each instructor. So, this application was made while evaluating the teaching performance of the 2021 Grade 3 History Course in Shenzhen Junior High School History Teaching. According to the established evaluation index system and comment set, the opinions of students and colleagues on the teacher's teaching performance were collected. Then the evaluation matrix of the indicators is formed. take the construction matrix R 1 For example, when considering "clear goals and objectives", 38% rated it "excellent",35% rated it "very good", and 25% rated it "good"", 2% of respondents rated it as "fair" or "poor";

When considering "clear, logical and innovative documentation", 25% rated it "excellent", 49% rated it "very good" and 22% rated it "good" , 4% of respondents rated it as "fair" and 0% rated it as "poor". Therefore, the matrix R1 can be deduced as follows: $R_1 = \begin{bmatrix} 0.38\ 0.35\ 0.25\ 0\ \ 0 \\ 0.25\ 0.49\ 0.22\ 0.04\ 0 \end{bmatrix}$

Similarly, get the matrix:

$R_2 = \begin{bmatrix} 0.16\ 0.67\ 0.17\ 0\ 0 \\ 0.13\ 0.62\ 0.19\ 0.06\ 0 \end{bmatrix}$, $R_3 = \begin{bmatrix} 0.01\ 0.53\ 0.25\ 0.21\ 0 \\ 0.45\ 0.36\ 0.19\ 0\ 0 \\ 0.38\ 0.59\ 0.05\ 0\ 0 \end{bmatrix}$

$R_4 = \begin{bmatrix} 0.07\ 0.37\ 0.56\ 0\ 0 \\ 0.25\ 0.71\ 0.05\ 0\ 0 \end{bmatrix}$, $R_5 = \begin{bmatrix} 0.14\ 0.56\ 0.22\ 0.09\ 0 \\ 0\ 0.15\ 0.20\ 0.65\ 0 \end{bmatrix}$ (7)

$$R_6 = \begin{bmatrix} 0\ 0.72\ 0.14\ 0.14\ 0 \\ 0.1\ 0.73\ 0.02\ 0.15\ 0 \\ 0.05\ 0.41\ 0.35\ 0.19\ 0 \end{bmatrix}$$

then we can get $B_1 = W_1R_1 = (0.444\ 0.536)\begin{bmatrix} 0.38\ 0.35\ 0.25\ 0\ 0 \\ 0.25\ 0.49\ 0.22\ 0.04\ 0 \end{bmatrix}$=(0.3027 0.4180 0.2289 0.0214 0)

$B_2 = W_2R_2 = (0.401\ 0.599)\begin{bmatrix} 0.16\ 0.67\ 0.17\ 0\ 0 \\ 0.13\ 0.62\ 0.19\ 0.06\ 0 \end{bmatrix}$= (0.1420 0.6401 0.1820 0.0359 0) (8)

$$B_3 = W_3R_3 = (0.3800\quad 0.3100\quad 0.3100)\begin{bmatrix} 0.01\ 0.53\ 0.25\ 0.21\ 0 \\ 0.45\ 0.36\ 0.19\ 0\ 0 \\ 0.38\ 0.59\ 0.05\ 0\ 0 \end{bmatrix}$$

1. =(0.2611 0.4959 0.1694 0.0798 0) (9)

$B_4 = W_4R_4 = (0.5360\quad 0.4440)\begin{bmatrix} 0.07\ 0.37\ 0.56\ 0\ 0 \\ 0.25\ 0.71\ 0.05\ 0\ 0 \end{bmatrix}$ (10)

=(0.1485 0.5136 0.3224 0 0)

$$B_5 = W_5R_5 = (0.510\quad 0.490)\begin{bmatrix} 0.14\ 0.56\ 0.22\ 0.09\ 0 \\ 0\ 0.15\ 0.20\ 0.65\ 0 \end{bmatrix}$$

=(0.0714 0.3591 0.2102 0.3644 0) (11)

$$B_6 = W_6R_6 = (0.3300\quad 0.3300\quad 0.3400)\begin{bmatrix} 0.07\ 0.37\ 0.56\ 0\ 0 \\ 0.25\ 0.71\ 0.05\ 0\ 0 \end{bmatrix}$$

2. =(0.0500 0.6179 0.1718 0.1603 0) (12)

We build the evaluation matrix R in the first layer according to the above matrix as follows:

$$R = \begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \\ B_5 \\ B_6 \end{bmatrix} = \begin{bmatrix} 0.3027 & 0.4180 & 0.2289 & 0.0214 & 0 \\ 0.1420 & 0.6401 & 0.1820 & 0.0359 & 0 \\ 0.2611 & 0.4959 & 0.1694 & 0.0798 & 0 \\ 0.1485 & 0.5136 & 0.3224 & 0 & 0 \\ 0.0714 & 0.3591 & 0.2102 & 0.3644 & 0 \\ 0.0500 & 0.6179 & 0.1718 & 0.1603 & 0 \end{bmatrix} \qquad (13)$$

The evaluation matrix R represents the membership value of each review, which is related to each factor in the evaluation index. Therefore, the comprehensive evaluation of its teaching performance is calculated as follows:

$$\mathrm{B} = \mathrm{W} * \mathrm{R}$$

$$= (0.182\ 0.157\ 0.180\ 0.164\ 0.104\ 0.212)\begin{bmatrix} 0.3027\ 0.4180\ 0.2289\ 0.0214\ 0 \\ 0.1420\ 0.6401\ 0.1820\ 0.0359\ 0 \\ 0.2611\ 0.4959\ 0.1694\ 0.0798\ 0 \\ 0.1485\ 0.5136\ 0.3224\quad 0\quad 0 \\ 0.0714\ 0.3591\ 0.2102\ 0.3644\ 0 \\ 0.0500\ 0.6179\ 0.1718\ 0.1603\ 0 \end{bmatrix} \qquad (14)$$

=（0.1668 0.5184 0.2119 0.0958 0）

The results showed that the probability of teaching performance being "very good" was 0.1668. The probability of "excellent", "good", "average" and “poor” were 0.05184, 0.2119, 0.0958, and 0, respectively. According to the principle of maximum membership, the comprehensive evaluation result of the lecturer's teaching performance is "very good." In addition, the B_1，B_2，B_3，B_4，$B_5 and B_6$ vector weights are his performance on the "Student Evaluation" and "Professionalism" factors that are inferior to other factors. Assessment results are based on input from students and peers and provide lecturers with advice on improving the quality of teaching. We interviewed grade level leaders and history teachers about the assessment results. They agreed that the assessment results obtained by the proposed framework are more transparent and objective. Furthermore, the proposed method makes it easier to interpret the lecturers' results and provides useful information for institutional managers. The information gathered during the assessment process helps maintain and improve the quality of teaching in educational institutions.

V. CONCLUSIONS

Evaluation of the effectiveness of history teaching is an effective means of maintaining the quality of teaching, so it has been widely concerned by educational institutions. This paper presents the evaluation index system of evaluation of the teaching effect of history and develops a framework for evaluating teaching performance based on the combination of fuzzy analytic hierarchy process and the comprehensive evaluation method. The application of fuzzy comprehensive evaluation for teaching performance evaluation can reflect the overall teaching level of teachers and reflect teachers' achievements in various evaluation factors. This helps teachers understand what needs to be improved to improve the quality of their teaching. One contribution of this method is the introduction of fuzzy analytic hierarchy process to determine the weights of factors and sub-factors in the evaluation index system. Because the fuzzy analytic hierarchy process can capture the ambiguity of human judgment, the weights derived in the index system are more objective and reasonable. This approach reduces subjectivity in the evaluation process. A case application shows the framework's applicability in providing a valuable tool in the teaching performance evaluation process. It is expected that this method can provide an effective, scientific and objective measure for evaluating the effectiveness of history teaching. Furthermore, this study presents a systematic framework for the fuzzy AHP approach in a group decision-making environment. Applying this framework results in highly consistent and accurate solutions. Therefore, it can also serve as a reference for management practitioners when solving decision-making problems.

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