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# Learner Behavior Analysis Method of Online Education Performance Evaluation

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**Abstract**

The paper presents a new model for evaluating online education performance based on the principle of analytic hierarchy process and fuzzy comprehensive evaluation. First an evaluation indicator system of online education performance is designed through analyzing the characteristics of online learners' behavior with more details in which all the evaluation indicators are classified into general indicators and key indicators according to its importance or concern degree, and the indicators with the same characteristics are clustered into an independent indicator to be evaluated, which can simplify the structure of the indicator system, decrease the number of indicators and improve evaluation accuracy; Secondly in constructing the comprehensive evaluation model for online education performance, analytic hierarchy process and fuzzy comprehensive evaluation are combined and two level fuzzy evaluation is adopted to satisfy the dynamics, subjective and transitional characteristics of indicators and improve evaluation accuracy.

**Keywords:** Multistage comprehensive fuzzy evaluation, Analytic hierarchy process, Learner behavior analysis

## 1. Introduction

Study on evaluation indicator system of online education performance in China mainly establishes evaluation system from two perspectives as process monitoring and overall monitoring. The former mainly includes that Wang, carries out whole-process multiple evaluation, combining formative evaluation with summative evaluation, combining self-evaluation, teacher evaluation and group evaluation, combining knowledge evaluation with multi-dimensional evaluation, combining individual evaluation with overall evaluation [1]; Cheng put forward the idea of satisfaction evaluation of learning process of remote education, having established satisfaction evaluation indicator system of learning process [2]. The latter mainly includes that Li based on building learning theory, have established evaluation system of online education performance, which includes such three major indicators as learning environment, learning behavior tracking and learning behavior analysis and evaluation generation [3]; Ya, on the basis of reference to evaluation on higher education undergraduate teaching work, from a global point of view, mainly carries out analysis on online education performance from such 7 aspects as talent training target, teachers construction, teaching process management, support service environment and resources, construction and management of off-campus learning center, teaching effect and climate for learning [4].

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In conclusion, structures of evaluation indicator system of online education built at home and abroad are relatively complicated with lots of evaluation indicators; moreover, there are both quantitative indicators and qualitative indicators in evaluation indicators, which lead to a difficult choice in subsequent evaluation method and non-guarantee of evaluation accuracy.

**2. Evaluation Method of this Paper**

In the design of evaluation system of online education performance, in allusion to the current situation of lots of indicators and complicated indicator system, the fuzzy clustering of evaluation indicators in this paper is key indicators and general indicators; key indicators are the ones required key focus in the evaluation, which can be the ones with great influence or the ones required improvement by specific enterprises. In consideration of learning subject of online education, the learning behavior analysis of learners is the most important indicator for performance appraisal of online education; thus, this paper takes learners behavior analysis as key indicators, and makes use of existing literature to carry out evaluation on other indicators; through this, the quantity and levels of indicators in the indicator system can be reduced, indicator system structure can be simplified, thereby improving evaluation accuracy and reliability, enhancing the pertinence, practicability and operability of study achievement on specific enterprises.

As to evaluation methods. In light of subjectivity, fuzziness, dynamics and intermediate transitivity of evaluation indicator of online education performance, it cannot be described and verified accurately and rigidly; this paper, through study on fuzzy membership functions of evaluation indicators, combines analytic hierarchy process with fuzzy hierarchy evaluation method to carry out comprehensive evaluation, so as to conquer the problems that quantitative method neglects the characteristic of real-time dynamics of influencing factors while qualitative method is relatively subjective, also conquer the problems that analytical hierarchy process has large error while evaluating multi-indicator system and rigidness determination of membership function in fuzzy evaluation method, and give play to the technical expertise of two evaluation methods; Secondly, by adopting secondary fuzzy evaluation, i.e. on the basis of primary fuzzy evaluation, cluster general indicators with similar features as an independent indicator for evaluation; finally carry out secondary fuzzy evaluation on key indicators and clustered general indicators to improve the evaluation accuracy of analytical hierarchy process and fuzzy evaluation, so as to build a new model for evaluation of online education performance, also hoping that the model can further enrich the theory and method of complicated system analysis.

**3. Steps of Fuzzy Overall Evaluation Method**

Fuzzy overall evaluation in this paper is conducted according to the following five steps.

(1) Establish Evaluation Element Set

Evaluation element set is an ordinary set constituted by all the elements influencing evaluation object; suppose there are n evaluation indicator elements expressed by $u_1$, $u_2$, $u_3$, …, $u_n$ respectively, then the set constituted by these n evaluation elements is called evaluation element set, i.e. $U=\{ u_1, u_2, u_3, \ldots, u_n \}$ [5].

(2) Confirm Evaluation Set

Evaluation set is also called judgment set, which is comprised of all the evaluation results of evaluator on evaluation object, is an ordinary set formed by all the possible evaluation results of evaluators on evaluation object. Evaluation results can be divided into m hierarchies according to actual demand of specific cases, which can be expressed by $v_1$, $v_2$, $v_3$, …, $v_m$ respectively, then evaluation set can be constituted as V={ $v_1$, $v_2$, $v_3$, …, $v_m$ }.

(3) Confirm the weight of evaluation indicator

The reasonable confirmation of indicator weight embodies the different weight relations among all the evaluation indicators in the system, increases the comparability among all the evaluation indicators and the effectiveness of evaluation result. AHP is objective with such merits as practicability, conciseness and systematisms. Thus, this paper adopts AHP to confirm the weights of all the evaluation indicators, obtaining the weight $w_i$ of each evaluation indicator $u_i$. The set constituted by each weight $w_i$ is called weight set W, as shown in formula 1.

$$W=\{ w_1, w_2, w_3, \ldots, w_n \} \quad \sum_{i=1}^{n} w_i = 1 \quad w_i \geq 0 \tag{1}$$

There are generally the following steps to confirm indicator weight by AHP:

The specific steps to calculate indicator weight by adopting AHP are as follows.

a. Construct Judgment Matrix

After building hierarchical structure, the subordination between elements in upper and lower hierarchies is confirmed. Suppose that taking top element U as criterion, the next hierarchical element dominated by it is $u_1$, $u_2$, …, $u_n$; corresponding weights $w_1$, $w_2$, …, $w_n$ of their relative importance towards U will be obtained through pairwise inter-comparison. Assign the value to indicators' relative importance based on scale table, n compared elements in the lower hierarchy consist of a pairwise inter-comparison judgment matrix $A=(a_{ij})_{m \times n}$ .

b. Calculate the Weights of All the Indicators

This paper adopts root method to calculate weight; steps are as follows:

(a) Calculate the product of each line in comparison matrix;

(b) Extract nth root of products obtained in step a;

(c) Total all the products obtained in step b;

(d) Weight $w_i$ is obtained through dividing values obtained in step b by values in step c.

c. Consistency Check of Judgment Matrix

While building judgment matrix, due to complexity of objective things, there are always errors in judgment matrix. Generally, there may be no complete consistency in judgment matrix, so consistency check of judgment matrix is required. Quantitative indicator used for measuring judgment matrix is called consistency indicator CI, as shown in formula 2.

$$CI=(\lambda_{max}-n)/(n-1) \tag{2}$$

In formula 2[2], $\lambda_{max}$ is the maximum eigenvalue of judgment matrix, n is the number of comparison indicator. $\lambda_{max}$ is calculated as follows: respectively multiply elements in each line of judgment matrix by vector component of weight W, then add, obtaining $Aw_i$; divide $Aw_i$ respectively by $w_i$, obtaining value $Aw_i/w_i$. $\lambda_{max}$ is the average value of $Aw_i/w_i$.

In order to confirm the allowed range of inconsistency degree, the corresponding average random consistency indicator RI of n can be looked for the following table.

Table 2. Average Random Consistency Indicator

| Order | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| RI | 0 | 0 | 0.58 | 0.90 | 1.12 |

At last, judge whether the matrix is consistent through consistency ratio CR, CR=CI/RI. If CR<0.1, the consistency of judgment matrix is acceptable. Whereas, if CR≥0.1, the consistency of judgment matrix is unacceptable; judgment matrix should be properly amended to keep the consistency of judgment matrix to certain extent.

(4) Single-factor Fuzzy Evaluation

Suppose that evaluation object carries out evaluation according to the ith factor in factor set U $u_i$ (i=1, 2, 3, …, n), the subordination of which as to the jth factor in evaluation set V $v_j$ (j=1，2，3，…， m) is expressed as $r_{ij}$, formula 3 can be used to show the evaluation result of the ith factor $u_i$.

$$R_i=\{ r_{i1}, r_{i2}, r_{i3} \ldots, r_{im} \} \tag{3}$$

$R_i$ in formula 3 is single-factor evaluation set, so formula 4 can be obtained, i.e. single-factor evaluation set of each factor.

$$R=\begin{bmatrix} R_1 \\ R_2 \\ \vdots \\ R_n \end{bmatrix}=\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix} \tag{4}$$

R in formula 4 is called single-factor evaluation matrix. $R_{ij}$ can be obtained through experts grading method, subordination function method or other managerial mathematical methods.

(5) Build Evaluation Model to Carry out Fuzzy Overall Evaluation

In consideration of difference importance of each factor, i.e. different indicator weights, it is necessary to combine the weight set W and R of all the evaluation indicators, to carry out overall evaluation, building overall evaluation model formula 5

$$\begin{aligned} B&=W\circ R \\ &=(w_1, w_2, \cdots, w_n)\circ\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix} \\ &=(b_1, b_2, \cdots, b_m) \end{aligned} \tag{5}$$

In formula 5, B is the result set of fuzzy overall evaluation, $b_j$ (j=1, 2, 3, …, m) is called fuzzy overall evaluation indicator, which judges the indicator subordination of the jth evaluation element in evaluation set while comprehensively considering the impact of all the indicators on evaluation object.

In the above evaluation process, symbol “o” is fuzzy synthetic operator, also called fuzzy operator, generally having the following four forms:

Model 1 M( ∧， ∨ )-Major Factor Determining Type, see formula 6

$$b_j=\bigvee_{i=1}^{n}(w_i \wedge r_{ij}) \quad (j=1, 2, \ldots, m) \tag{6}$$

“∨” in formula 6 represents large-taking symbol, “∧” represents small-taking symbol, the model features the focus on major factors, and that other factors have little impact on results. This operation sometimes makes decision result not easy to be distinguished.

Model 2 M( · ， ∨ )-Major Factor Highlighting Type, see formula 7.

$$b_j=\bigvee_{i=1}^{n}(w_i r_{ij}) \tag{7}$$

“ · ” in formula 7 represents multiplication, the model first multiply species of attribute by single factor subordination, then get a greater one, the feature of which is to highlight major factor and ignore the role of secondary factor.

Model 3 M(∧, ⊕ ) - Major Factor Highlighting Type 8

$$b_j = \oplus\sum_{i=1}^{n}(w_i \wedge r_{ij}) \tag{8}$$

"⊕" in formula 8 is bounded sum, i.e. $a \oplus b = \min(1,\ a+b)$, $\oplus\sum_{i=1}^{n}$ is to get a sum of n under the operation of ⊕, i.e. $b_j = \min\left[1, \sum_{i=1}^{n}(w_i \wedge r_{ij})\right]$

Model 4 M( · , + )——Weighted Average Type, see formula 9

$$b_j = \sum_{i=1}^{n}(w_i r_{ij}) \quad (j=1,\ 2,\ \ldots,\ m) \tag{9}$$

The model first multiplies $w_i$ by $R_{ij}$, then do the sum operation. The model, according to the weight of indicator factor, evenly gives consideration to all the indicator factors, especially applicable to the situation when multiple factors jointly work. Therefore, the competitiveness evaluation of commercial banks in this paper adopts that model for calculation.

## 4. Multi-hierarchy Fuzzy Overall Evaluation

In actual cases, if the evaluation object is multiple factors and the weight distribution among all the factors is relatively balanced, we can adopt multi-hierarchy model for evaluation. Following is the introduction to build third-grade model.

(1) Divide Factor Set

Divide Factor U into several hierarchies U={ $u_1$, $u_2$, $u_3$, …, $u_n$ }, conditions satisfied formula 10

$$\begin{aligned} &u_i \cap u_j \neq \varphi, \quad when \quad i \neq j \\ &u = \bigcup_{i=1}^{n} u_i \end{aligned} \tag{10}$$

U={ $u_1$, $u_2$, $u_3$, …, $u_n$ } is called the first factor set.

Suppose $u_i$={ $u_{i1}$, $u_{i2}$, $u_{i3}$, …, $u_{ik}$ }, i=1,2, …, n is called the second factor set; $u_{ij}$={ $u_{ij1}$, $u_{ij2}$, $u_{ij3}$, …, $u_{ijl}$ }, i=1,2, …, n, j= i=1,2, …, k is called the third factor set.

(2) Carry out first-hierarchy fuzzy overall evaluation on $u_{ij}$

Suppose that the weight set of $u_{ij}$={ $u_{ij1}$, $u_{ij2}$, $u_{ij3}$, …, $u_{ijl}$ } is $w_{ij}$={ $w_{ij1}$, $w_{ij2}$, $w_{ij3}$, …, $w_{ijl}$ },

According to formula 5, overall evaluation is $w_{ij}oR_{ij}=B_{ij}$, i=1,2,…, n,j= i=1,2, …, k.

(3) Carry out second-hierarchy fuzzy overall evaluation on $u_i$

Suppose that the weight set of $u_i$={ $u_{i1}$, $u_{i2}$, $u_{i3}$, …, $u_{ik}$ } is $w_i$={ $w_{i1}$, $w_{i2}$, $w_{i3}$, …, $w_{ik}$ }, according to formula 5, overall evaluation is $w_ioR_i=B_i$, i=1,2, …, n。

(4) Carry out third-hierarchy fuzzy overall evaluation on u

Suppose that the weight set of U={ $u_1$, $u_2$, $u_3$, …, $u_n$ } is W={ $w_1$, $w_2$, $w_3$, …, $w_n$ }, according to formula 5, overall evaluation is WoR =B, at last, adopt weighted average method to get evaluation result.

## 5. Conclusions

There is a favorable application prospect for the analysis and competitiveness evaluation of online education based on the principle of fuzzy analysis. This paper, on the basis of the principle of learner behavior analysis, analyzes and builds comprehensive evaluation system of online education, makes use of multi-hierarchy fuzzy evaluation method to establish comprehensive evaluation model for online education, also carries out case study taking the data of distance training schools of three different universities as an example.

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