A NEW MODEL OF COURSE ASSESSMENT BASED ON THE FLIPPED CLASSROOM APPROACH APPLIED TO “MODERN LOGISTICS TECHNOLOGY” COURSE

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As an innovative approach, flipped classroom changes the “studying in class + practicing after class” mode into “studying before class + explaining in class” by reversing the two stages that of knowledge transfer and knowledge internalization. The changing of teaching mode brings the changing of assessment methods, because the traditional assessment methods are no longer suitable to the requirements of a new teaching model. In this paper at first, the drawbacks of traditional assessment were described, and then the diversified course assessment index system in on-line and offline forms was established. The course assessment was evaluated using the combination of Analytic Hierarchy Process (AHP) and Fuzzy Comprehensive Evaluation (FCE). This new assessment method changes the traditional result-oriented evaluation to the process-oriented one, the teacher evaluation to the students’ evaluation, realizing the combination of quantitative and qualitative evaluation mode and promoting the students’ autonomous learning, processive learning and experiential learning, giving full play to the feedback, improvement and strengthening function of the assessment.

Keywords: flipped classroom, course assessment, AHP-FCE.
and randomness, which is not favorable for improvement of teachers’ level and for mobilizing students’ learning enthusiasm. Furthermore, a test consists of multiple choice questions, true and false statements, fill-in-the-blanks, quantitative problems, short answers, most of which are to test the memorized knowledge, ignoring the application of knowledge and personal development. Students mostly cram for the final; even someone who never pays attention in class will try to cheat at examination. Therefore, such a single, result-oriented and subjective assessment method neither assesses the extent of students’ learning nor improves student’s thinking, values, and efficiency. It is also not suitable for a new teaching model [2].

3. The mathematical model of AHP-FCE

The analytic hierarchy process (AHP) is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It has particular application in group’s decision-making and is used globally in a wide variety of situations. This method makes use of both qualitative and quantitative analysis to develop the inter-relationship among the indexes and establish the judgement matrix. In parallel, fuzzy comprehensive evaluation (FCE) method is a comprehensive evaluation method based on fuzzy mathematics, which can transform the qualitative evaluation into the quantitative evaluation according to the membership degree theory of fuzzy mathematics. This method can solve the ambiguous and hard-to-quantify problems and, therefore, is suitable for solving various non-deterministic problems. Usually, the final examination uses a grading system (excellent, good, medium, passing, failing), but the definition of each level is not clear and the grade is ambiguous. So, the fuzzy comprehensive evaluation is an effective evaluation method and, particularly suitable, for the flipped classroom assessment. So, this paper combined AHP/FCE methods that provided a solution to the problem solving, which makes use of the AHP to calculate the weight values first, and, then, implement the FCE to carry out a from-quantitative-to-quantitative assessment.

The main process is as follows [3, 4]:

(1) Identifying the affecting factor set

For fuzzy evaluation, factors that affect the parameter’s value determination should first be identified. If the known affecting factors are \( u_1, u_2, ..., u_m \), the set these parameters can make up is \( U = \{u_1, u_2, ..., u_m\} \), and this factor set is a common set.

(2) Determining factor weights set

Each factor has a different impact on, or importance to the value determination of parameters. In other words, the factors have different weights for parameter values. The set composed of various weights of all factors for parameter value determination is called the factor weights set, which is represented as \( A = \{a_1, a_2, ..., a_m\} \). If \( a_i \) represents the weight of factor No. \( i \), the weight of each factor should satisfy Equation (1).

\[
\sum_{i=1}^{n} a_i = 1, a_i \geq 0 .
\]  

The Analytic Hierarchy Process operation can be divided into the following five steps:

Step 1: Define the decision-making problem.

Step 2: Create a hierarchical structure.

Step 3: Create a pairwise comparison matrix. Table 1 is the evaluation measurement and relative definition of AHP.

Step 4: Calculate the eigen values.

Step 5: Conformance test.

Eigen values in step 4 can be calculated in the following ways: Normalization of the Row Average (NRA), Average of Normalized Columns (ANC), Normalization of the Geometric Mean of the Rows (NGM), and Normalization of the Average Reciprocal of Columns. The consistency test in step five is to make sure that the evaluation results are consistent when the experts are conducting pairwise comparisons, which means that the experts’ preference for criteria is transitive. Saaty suggested that consistency index (CI) and consistency ratio (CR) be used for the test. If CI and CR are both less than 0.1, it means that the pairwise matrix is consistent. If the matrix is not consistent, the equation of CI and CR is as follows:

\[
CI = \frac{\lambda_{\text{max}} - n}{n - 1} ,
\]

\( \lambda_{\text{max}} \) is the largest eigenvalue of the matrix, \( n \) is matrix order (number of parameters).

\[
CR = CI/RI \quad CR < 0.1 \quad \text{ok}
\]

\( C:R = \) Consistency ratio

\( C:I = \) Consistency index

\( R:I = \) Random index,

where \( n \) is the number of evaluation criteria; \( RI \) is random index whose value increases if the number of criteria increases, as shown in Table 2.
Table 1

<table>
<thead>
<tr>
<th>Evaluation measurement</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Equal importance</td>
</tr>
<tr>
<td>3</td>
<td>Slight importance</td>
</tr>
<tr>
<td>5</td>
<td>Essential importance</td>
</tr>
<tr>
<td>7</td>
<td>Very strong importance</td>
</tr>
<tr>
<td>9</td>
<td>Absolute importance</td>
</tr>
<tr>
<td>2, 4, 6, 8</td>
<td>Intermediate</td>
</tr>
</tbody>
</table>

Table 2

<table>
<thead>
<tr>
<th>Order N</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI</td>
<td>0</td>
<td>0</td>
<td>0.58</td>
<td>0.90</td>
<td>1.12</td>
<td>1.24</td>
<td>1.32</td>
<td>1.41</td>
</tr>
</tbody>
</table>

(3) Establishing a parameter evaluation set
An evaluation set is the set of various possible evaluation results given by evaluators for the evaluation objects, shown as V. V = {v₁, v₂, ..., vₙ}; vi(i = 1, 2, ..., n) represents all of the possible evaluation results. The purpose of fuzzy evaluation is to obtain an optimal evaluation result from the evaluation set based on the comprehensive consideration of all affecting factors. As vi and V have the relation of common set, the evaluation set is also a common set.

(4) Building a single factor evaluation matrix
A single factor fuzzy evaluation system evaluates single factors to determine the membership of an evaluation object to an evaluation set. The evaluation object is evaluated as the No. i factor ui in the factor set, and the membership of No. j factor Vᵢ in the evaluation set is rᵢj, so the evaluation result of No. i factor uᵢ can be expressed as:

\[ R_i = \frac{r_{i1}}{v_1} + \frac{r_{i2}}{v_2} + ... + \frac{r_{in}}{v_n} \]  

where Rᵢ is called a single factor evaluation set. As a fuzzy subset, it can be expressed as Rᵢ = {rᵢ₁, rᵢ₂, ..., rᵢₙ}. Similarly, the single factor evaluation set corresponding to each factor is as follows:

\[ R_1 = \{r_{11}, r_{12}, ..., r_{1n}\} \]
\[ R_2 = \{r_{21}, r_{22}, ..., r_{2n}\} \]
\[ \vdots \]
\[ R_m = \{r_{m1}, r_{m2}, ..., r_{mn}\} \]

The memberships of each single factor evaluation set constitute a fuzzy matrix, where R is called the single factor evaluation matrix, as shown in Equation (6). R is a fuzzy matrix, and it can also be regarded as a U-V fuzzy relationship matrix, called fuzzy transformation.

(5) When conducting fuzzy composition, if the fuzzy evaluation matrix of a program to an evaluation object is:

\[ R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1j} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2j} & \cdots & r_{2m} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ r_{i1} & r_{i2} & \cdots & r_{ij} & \cdots & r_{im} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nj} & \cdots & r_{nm} \end{bmatrix} \]  

then the comprehensive fuzzy evaluation with weighting considered and the product of fuzzy matrix is:

\[ B = A \bullet R = [b_1, b_2, ..., b_j, ..., b_m] \]  

In the above equation, the symbol “●” represents fuzzy composition. The weighted fuzzy matrix A and factor evaluation matrix R have a variety of compositions. This study will use different compositions to work out various evaluation results for comparison and analysis. The model selected is as follows:

when the composition is done by \( M(\cdot, \oplus) \) algorithm

\[ b_j = \min \left( \sum_{i=1}^{m} a_{ij} r_{ij} \right) ; j = 1, 2, ..., n \]

4. The course assessment based on AHP-FCE
4.1. Establishment of the evaluation indicator system
On the foundation of FCE, the selection of evaluation indexes will directly affect the accuracy of comprehensive evaluation. Basing on researches of domestic and foreign scholars for the examining model and the exam outline of the course, the new examination method of the Modern Logistics Technology is as follows: formal assessment and project result. In this paper, the evaluation system is composed of 4 indicators and 12 corresponding sub-indicators. This is shown in Table 3.
4.2. Determination of weights of AHP-based indicator system

The indicator system can be divided into three levels: level A, level B, level C from top to bottom. In the evaluation indicator system, the main criterion level and branch criterion level represent Level B indicator and Level C indicator respectively: \( X = (X_1, X_2, X_3) \) and \( X_1 = (X_{11}, X_{12}, X_{13}), X_2 = (X_{21}, X_{22}, X_{23}), X_3 = (X_{31}, X_{32}), X_4 = (X_{41}, X_{42}, X_{43}, X_{44}) \) specifically.

According to the level structure of the evaluation indicator system of course assessment, the judgment matrix \( P \) of level B indicator \( X \) can be built based upon the importance of each factor, as shown in Table 4.

\[
| \text{Table 4} |
|-----------------|-------------------|-----------------|
| P               | X1    | X2    | X3    | X4    |
| X1              | 1     | 1/2   | 4     | 3     |
| X2              | 2     | 1     | 5     | 4     |
| X3              | 1/4   | 1/5   | 1     | 1/4   |
| X4              | 1/3   | 1/4   | 4     | 1     |
| weight          | 0.296 | 0.478 | 0.069 | 0.157 |
| \( \lambda_{\text{max}} \) | 4.194 | 0.065 | 0.0727 | < 0.1 |
| Conform to the consistency requirement |

Upon calculation, the maximum eigenvalue of the judgment matrix \( P \) is \( \lambda_{\text{max}} = 4.194 \). In order to check the consistency of the matrix, it is required to calculate the consistency indicator.

\[
\text{CI} = \frac{\lambda_{\text{max}} - n}{n-1} = \frac{4.194 - 4}{4 - 1} = 0.065 \quad (9)
\]

The average random consistency indicator is \( RI = 0.89 \). The random consistency ratio:

\[
\text{CR} = \frac{\text{CI}}{RI} = \frac{0.065}{0.89} = 0.073 \quad (10)
\]

Therefore, the AHP sequencing result is considered to be of high consistency, that is, the allocation of weight coefficient is very reasonable.

The corresponding eigenvector: (0.296 0.478 0.069 0.157).

Similarly, the weight ratios of Level C indicators \( X_1, X_2, X_3 \) and \( X_4 \) are as follows (Table 5–8).

\[
| \text{Table 5} |
|-----------------|-------------------|-----------------|
| P1              | X_{11} | X_{12} | X_{13} |
| X_{11}          | 1      | 5      | 3     |
| X_{12}          | 1/5    | 1      | 1/2   |
| X_{13}          | 1/3    | 2      | 1     |
| Weight          | 0.648  | 0.122  | 0.230 |
| \( \lambda_{\text{max}} \) | 3.004 | 0.0020 | 0.0038 | < 0.1 |
| Conform to the consistency requirement |

\[
| \text{Table 6} |
|-----------------|-------------------|-----------------|
| P2              | X_{21} | X_{22} | X_{23} |
| X_{21}          | 1      | 2      | 5     |
| X_{22}          | 1/2    | 1      | 3     |
| X_{23}          | 1/5    | 1/3    | 1     |
| Weight          | 0.582  | 0.309  | 0.109 |
| \( \lambda_{\text{max}} \) | 3.0037 | 0.0019 | 0.0036 | < 0.1 |
| Conform to the consistency requirement |

\[
| \text{Table 7} |
|-----------------|-------------------|-----------------|
| P3              | X_{31} | X_{32} |
| X_{31}          | 1      | 1     |
| X_{32}          | 1      | 1     |
| Weight          | 0.5    | 0.5   |
| \( \lambda_{\text{max}} \) | 2.000 | 0.0 | 0.1 |
| Conform to the consistency requirement |

Therefore, the AHP sequencing result is considered to be of high consistency, that is, the allocation of weight coefficient is very reasonable.

The corresponding eigenvector: (0.296 0.478 0.069 0.157).

Similarly, the weight ratios of Level C indicators \( X_1, X_2, X_3 \) and \( X_4 \) are as follows (Table 5–8).
4.3. Establishing decision set for the course assessment

We established an evaluation system, which adopts five evaluation ratings (excellent, good, medium, pass, fail) based upon group discussion and expert evaluation.

4.4. Establishment of the fuzzy relationship from the factors set to the decision set

There are qualitative and quantitative indexes in Table 3. For the quantitative index (x11, x32), we can convert hundred mark system into five grade system, such as excellent (90–100), good (80–89), fair (70–79), pass (60–69), fail (0–59). Assuming there are 20 tests in a semester, the result of a student is 8 times (90–100), 5 times (80–89), 5 times (70–79), 2 times (60–69), the fuzzy matrix of it is (0.4, 0.25, 0.25, 0.1, 0). The remaining indicators are qualitative ones. Assuming there are 39 students, one teacher, in total 40 in a class, for a certain index, 12 people think it is excellent, 15 think it is good, 13 think it is medium, so the fuzzy matrix of it is (0.3, 0.375, 0.325, 0.0).

The whole class and a teacher subjectively evaluate and grade all factors of the indicator system according to the actual conditions. Based upon the analysis of statistical data of sampling survey FCE matrix set can be gained. Here is an example of a student’s performance in a semester.

\[
R_{p1} = \begin{bmatrix}
0.2 & 0.4 & 0.2 & 0.2 & 0 \\
0.3 & 0.5 & 0.1 & 0.1 & 0 \\
0.2 & 0.4 & 0.3 & 0.1 & 0
\end{bmatrix}, \quad R_{p2} = \begin{bmatrix}
0.3 & 0.5 & 0.2 & 0 & 0 \\
0.2 & 0.3 & 0.4 & 0.1 & 0 \\
0 & 0.2 & 0.5 & 0.3 & 0
\end{bmatrix}, \quad (11)
\]

\[
R_{p3} = \begin{bmatrix}
0 & 0.3 & 0.4 & 0.3 & 0 \\
0.4 & 0.5 & 0.1 & 0 & 0
\end{bmatrix}, \quad R_{p4} = \begin{bmatrix}
0.2 & 0.3 & 0.4 & 0.1 & 0 \\
0 & 0.2 & 0.4 & 0.4 & 0 \\
0.1 & 0.2 & 0.3 & 0.4 & 0 \\
0.4 & 0.5 & 0.1 & 0 & 0
\end{bmatrix}
\]

4.5. Fuzzy comprehensive evaluation

(1) Fuzzy evaluation of index layer

\[
A_1 = W \bullet R = \begin{bmatrix}
0.648 & 0.122 & 0.230 \\
0.212 & 0.412 & 0.211 \\
0.165 & 0.015 & 0.0
\end{bmatrix}, \quad (12)
\]

Upon normalization, the comprehensive evaluation vector is, so similarly,

\[
A_2 = (0.236, 0.406, 0.294, 0.064, 0), \\
A_3 = (0.200, 0.400, 0.250, 0.150, 0), \quad (13)
\]

\[
A_4 = (0.184, 0.298, 0.264, 0.254, 0)
\]

(2) Fuzzy evaluation to the overall performance of the student

\[
A = W \bullet R = \begin{bmatrix}
0.212 & 0.412 & 0.211 & 0.165 & 0 \\
0.236 & 0.406 & 0.294 & 0.064 & 0 \\
0.200 & 0.400 & 0.250 & 0.150 & 0 \\
0.184 & 0.298 & 0.264 & 0.254 & 0
\end{bmatrix}, \quad (14)
\]

\[
=(0.218, 0.391, 0.262, 0.136, 0)
\]
Инновационная модель оценки курса «современные технологии логистики» на основе технологий «перевернутого класса»

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Технология «перевернутого класса» представляет собой инновационную форму процесса изучения учебной информации, в которой изучение материала идет перед занятием, а проверка усвоения материала и консультирование происходит на аудиторных занятиях, что модифицирует традиционную форму, когда изучение новой информации идет под руководством преподавателя, а дома студенты отрабатывают учебный материал. Изменение формы обучения приводит к изменению методов оценки, поскольку традиционные методы оценки больше не удовлетворяют требованиям новой учебной модели. В этой статье описаны недостатки традиционных методов оценок результатов обучения, и представлена диверсифицированная система оценки курса, интегрирующая онлайновые и офлайновые формы. Результаты обучения были оценены с использованием метода многофакторного анализа представляющего собой комплексную оценку обучения. При новом методе оценки акцент делается на процессуальной и эмпирической составляющих усвоения содержания образования обучающимися, поощрении их самостоятельности, сочетании количественного и качественного способов оценивания, что способствует полноценной обратной связи, в отличие от традиционной оценки, ориентированной на результат.

Ключевые слова: технология «перевернутого класса», оценка курса, процесс аналитической иерархии, многофакторный анализ.

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