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### **Research on Assessment System of Classroom Teaching Quality Based on Fuzzy Analytical Hierarchy Process and Fuzzy Comprehensive Assessment –Take Northwest University for Nationalities as an example**

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#### Abstract

Since the classroom teaching activities have the characters of various forms, complicated contents which make the teaching quality assessment be easily affected by subjective and objective factors. On the basis of fuzzy analytical

hierarchy process, this article introduces Fuzzy Comprehensive Assessment Method to try to build a teaching quality assessment model includes fuzzy analytical hierarchy process with comprehensive assessment and provides mathematical examples. By taking the tests of multigrain data and the comparison of results, the application shows that this teaching quality assessment model includes fuzzy analytical hierarchy process with comprehensive assessment can assess the teaching quality of the classroom teaching activities of teachers scientifically and reasonably, and there is certain practical value.

Keywords: CLASSROOM TEACHING QUALITY, TEACHING ASSESSMENT, FUZZY ANALYTICAL HIERARCHY PROCESS, FUZZY COMPREHENSIVE ASSESSMENT METHOD, ASSESSMENT MODEL

### 1. Introduction

Higher education is the most important element of national education. The level of higher education quality affects the quality of national talents and the developing level and speed of national economic construction. Since the 1990s, with the expansion of the scale of schools of Chinese higher education each year, especially the general institutes of higher education have been influenced by the increasing enlargement of teaching resource gap, structural decline of quality of students, the difficulty to ensure the teaching quality or even the decline of teaching quality have become a general issue focused by the society.

The way to ensure and improve teaching quality with the current resource has become the core problem of higher education development. And the scientific assessment of teaching quality is the key problem to ensure teaching quality. Main teaching form of higher education is classroom teaching, so classroom teaching quality assessment becomes the key link to ensure and improve the quality of higher education.

Development of higher education of national minorities is an important element of Chinese higher education, and higher institutes of nationalities are the important bases of higher education to serve national minorities and territory of nationalities. Higher institutes of nationalities have a special status and effect on the development of higher education for minorities. Since students of minorities are the main sources of students of higher institutes of nationalities have unique major features and school-running characteristics, this kind of university has become the import channel for the minorities to accept higher education. Under the background of general extension of the scale of higher education in China, the difference between the teaching quality and quantity of students of institutes of nationalities has been more and more significant. Due to the difference of history, geography and economic development level, the development of teaching quality of higher education for minorities is relative weak when compared to that of the national average level.

Highly educated teacher is a big lack in institutes of nationalities, and basis of students is generally low. Till 2013, there are totally 15 institutes of nationalities in China. Although the institutes of nationalities only occupy 1.3% of the total amount of common colleges and universities in China, they accept 1/10 of the students of the minorities in the whole country, covering 55 minorities. Among these institutes, students of minorities account for more than 55% of the total amount of students. In 2013, the internal students of the Chinese institutes of nationalities have exceeded 0.4 million, increasing 773% when compared to that in 1998. The growth range of internal students of the common colleges and universities in China at the same period is 458%. This indicates that there is still a big difference between the speed of development of common colleges and universities in China, though the institutes of nationalities develop rapidly. It can be concluded from this that the institute of nationalities provides more entrance opportunities for students of the minorities mainly by rapid connotative development under the almost unchanged quantity of institutes. And this has been the actual condition generally existing in the common colleges and universities in China. For example, the Northwest University for Nationalities. There are currently 26 teaching units and 61 undergraduate majors in the university, and it has now 25874 students from 56 nationalities. For a university for nationalities with so many students and majors, the construction of the teaching quality not only affects the quality of education, but it also will influence the cultivation of talents of the minorities and stability of economic and social development in territories of nationality [1].

### 2. Arrangement of Teaching Quality Assessment Indicator System

Based on concluding experience from other universities, deep investigation and research and practical situation of itself, the Northwest University for Nationalities establishes relatively reasonable teaching quality assessment system and standards meeting practical situation of universities for nationalities based on different subjects by conforming to the

guiding ideology of the new round undergraduate assessment of Ministry of Education, that is, rules of guidance to different categories. With the practical operation of this assessment system, it solves the problem that the assessment standards of the old system can't fully and objectively reflect the major features and ignore the factors affecting learning effect of students; and it also presents some weaknesses. For example, the indistinct weight distribution of assessment indicator and inability to provide quantitative interpretation of reasonability of each professional assessment indicator. Considering the teaching process of teacher has uncertainty, the classroom teaching is indistinct and assessment process of teaching quality has non-linear features, the quantitative analysis method by using fuzzy analytical hierarchy process and fuzzy comprehensive assessment is used for quantitative analysis on the teaching quality assessment system of Northwest University for Nationalities under the framework of guidance to different categories.

### 2.1. Basic Principles of Constructing Classroom Teaching Quality Assessment Indicator System

The teaching quality assessment involves complicated departments and personnel, so we need to firstly build an expert group consisting of supervi-

sors and teachers of the university to confirm and assess the indicator system and index value of relative importance. Based on practical needs of classroom teaching quality assessment, the set of indicator system shall insist on principles below. The first one is scientificity, that is to say, the design of assessment indicator shall conform to basic principles of pedagogy and psychology, and shall objectively reflect the true internal law, status, existing problems and development potential of teaching; the second is applicability, that is to say, the designed assessment indicator system and results of that shall be applicable for different majors and courses and shall be convenient to compare with each other. The third is systematicness and simplicity. We not only shall insist on systematic conception and overall consider the complicated factors depending on and restraining each other, but should also avoid excessively complicated indicator system. And clear order and distinct hierarchical structure should be held and operability on data collection and later assessment shall be available [2-3].

### 2.2. Classroom Teaching Quality Assessment

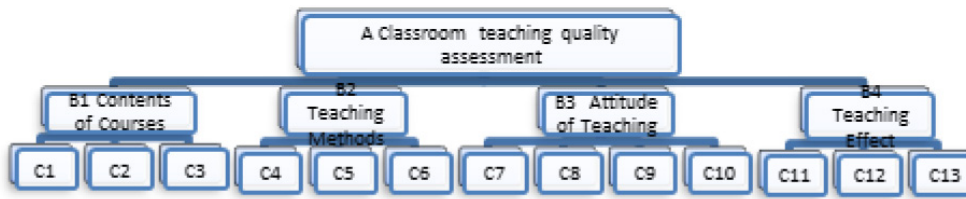
Based on the principles above, the classroom teaching quality assessment indicator system is established, as shown in Table 1.

**Table 1.** Classroom Teaching Quality Assessment Indicator System

Overall Target	Indicator System	
	Primary Indicator B	Secondary Indicator C
A Classroom Teaching Quality Assessment	B1 Contents of Courses	C1: Rich contents of courses and large amount of information. Conform to teaching program.
		C2: Pay attention to classroom climate to avoid vapidly. Initiate students' learning initiative.
		C3: Accurately teach basic concepts and theories. Clear thought, focused points and appropriate difficulties.
	B2 Teaching Methods	C4: Absorb fresh teaching results, and analyze and discuss based on teaching.
		C5: Pay attention to combining theory and practice, and appropriate examples.
		C6: Appropriately and effectively use modern teaching means/clean blackboard-writing, and image and text shall be well arranged.
	B3 Attitude of Teaching	C7: Fully devoted to teaching with appropriate emotion.
		C8: Teach in Mandarin (except for course of minority language and foreign language) with standard and clear tone.
		C9: Well prepare lessons and complete teaching documents.
		C10: Well communicate with students and encourage students to express opinions.
	B4 Teaching Effect	C11: Enlighten students to actively think, teach methods to the students and emphasize cultivation of students' innovation ability.
		C12: Strong ability of organizing teaching, and effective management of teaching order.
		C13: Appropriate selection of text books and reference materials to achieve good performance.

According to the indicator system in Table 1, the hierarchical structure of multilevel fuzzy analysis as-

essment model for teaching quality assessment is established [4-5], as shown in Figure 1.



**Figure 1.** Hierarchical structure of multilevel fuzzy analysis assessment model for teaching quality assessment

### 3. Improved Teaching Quality Assessment Model Based on Multilevel Fuzzy Analysis

#### 3.1. Analysis Confirmation of Weight

Since T, L, Saaty, American professor of operational research, proposed analytic hierarchy process in 1970s, this method has been widely used in many fields [5]. Analytical hierarchy process is a kind of multi-objective decision analytic method with combination of qualitative analysis and quantitative analysis. It fully uses expert knowledge and subjective experience, and applies mathematics to carry out rigorous logical reasoning, to remove subjectivity as much as possible. During the confirmation of weight, the reasonability of weight can be confirmed by judging whether the matrix has satisfactory consistency, so as to make the weight of each involved indicator more conform to the objective reality, which has effectively improved the accuracy and objective fairness of results of fuzzy comprehensive assessment [6-8].

##### 3.1.1. Function for judging and confirming the degree of importance

Assuming a function  $f(x, y)$ , it represents the scale of significance between  $x$  and  $y$  for the whole. In order to confirm the detailed data of degree of importance, we agree that  $f(x, y) = \frac{1}{f(y, x)}$ . Professor T, L, Saaty proposed a proportional scale of 1~9, as shown in Table 2.

**Table 2.** Table for Judging Degree of Importance

Degree of Importance	$f(x, y)$	$f(y, x)$
$x$ and $y$ "are of equal importance"	1	1
$x$ is "slightly more important" than $y$	3	1/3
$x$ is "obviously important" than $y$	5	1/5
$x$ is "strongly important" than $y$	7	1/7
$x$ is "absolutely important" than $y$	9	1/9
$x$ is more between each grade than $y$	2, 4, 6 and 8	1/2, 1/4, 1/6 and 1/8

##### 3.1.2. Establishment of Judgment Matrix

Assume  $X = \{x_1, x_2, \dots, x_n\}$  is a set of all factors. According to Table 2, compare factors two by two

and establish the judgment matrix  $C = (c_{ij})_{m \times n}$  as below:

$$C = \begin{bmatrix} c_{11} & c_{12} & \dots & c_{1n} \\ c_{21} & c_{22} & \dots & c_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ c_{m1} & c_{m2} & \dots & c_{mn} \end{bmatrix} \quad (1)$$

In the formula,  $c_{ij} = f(x_i, x_j)$ .

##### 3.1.3. Calculation of Weight

According to judgment matrix  $C$ , solve its maximum eigenvalue  $\lambda_{\max}$ , and solve the feature vector of judgment matrix related to  $\lambda_{\max}$ :

$$\xi = (\chi_1, \chi_2, \dots, \chi_n) \quad (2)$$

After impose normalization processing on feature vector, the obtained  $\xi$  is weight of each involved indicator, that is,

$$A = \{a_1, a_2, \dots, a_n\} \quad (3)$$

In order to inspect whether different judgment matrixes have satisfactory consistency, the formula below can be used for inspection. During the inspection, the ration of coincident indicator (CI) of judgment matrix to average random consistency index (RI) is used for judging. Here, CI of judgment matrix is as formula below:

$$CR = \frac{CI}{RI} \quad (4)$$

In the formula, CR is random consistency ratio of judgment matrix. When  $CR < 0.10$ , in indicates that the judgment matrix has satisfactory consistency, which shows that the weight distribution of this matrix is reasonable and results are acceptable, or otherwise, adjustment shall be conducted on the judgment matrix, until satisfactory consistency is achieved[9].

CI of judgment matrix is defined as,

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (5)$$

For judgment matrix of order 1~9, values of RI are shown in Table 3.



**Table 3.** RI (average random consistency index)

Order of Matrix	1	2	3	4	5
RI	0	0	0.52	0.89	1.12
Order of Matrix	6	7	8	9	
RI	1.26	1.36	1.41	1.46	

**3.2. Basic Principles of Fuzzy Comprehensive Assessment**

Fuzzy e assessment is to comprehensively assess matters by using fuzzy mathematics under full consideration of multi factors. Assume m kinds of factors of the objective under assessment are:

$$U = \{u_1, u_2, \dots, u_m\} \tag{6}$$

n kinds of decision of each factor at its state are:

$$V = \{v_1, v_2, \dots, v_n\} \tag{7}$$

When conducting fuzzy comprehensive assessment, there are two kinds of fuzzy sets. The first one is degree of importance of each factor in marking factor set U, presented as fuzzy weight vector of factor set U,  $A = \{a_1, a_2, \dots, a_m\}$ ; Another is fuzzy relation of  $U \times V$ , presented as  $m \times n$  fuzzy matrix R. These two fuzzy sets both present people’s values or preference structure. We can get a fuzzy subset on V,  $B = \{b_1, b_2, \dots, b_n\}$ , by carrying out certain blurring operation on two kinds of set. It can be concluded that fuzzy comprehensive assessment is to find fuzzy weight vector  $A = \{a_1, a_2, \dots, a_m\} \in F(U)$  and get a fuzzy change  $f$  from factor set U to V, so we can establish fuzzy matrix as below:

$$R = [r_{ij}]_{m \times n} \in f(U \times V) \tag{8}$$

In the formula,  $[r_{ij}]$  stands for factor  $u_i$ , with degree of remark  $v_j$ , based on which the fuzzy comprehensive assessment can be solved as below:

$$B = \{b_1, b_2, \dots, b_n\} \in F(V) \tag{9}$$

In the formula,  $b_i$  stands for degree of all remarks  $v_i$  attributing to the objects under assessment, that is to say, degree of membership of  $v_i$  to fuzzy set B [10-12].

**3.3. Establishment of Fuzzy Remark Set and Membership of Assessment Grade**

When conducting fuzzy analytical hierarchy process, the number of remark grade will generally be great than or equal to 4 and not more than 9.4 grades of remark set will be selected for teaching quality assessment, that is, remark set {excellent, good, medium, and poor}.

$$E = \begin{bmatrix} e_{11} & e_{12} & \dots & e_{14} \\ e_{21} & e_{22} & \dots & e_{24} \\ \vdots & \vdots & \vdots & \vdots \\ e_{n1} & e_{n2} & \dots & e_{n4} \end{bmatrix} \tag{10}$$

In the formula,  $n$  is number of indicator for assessment,  $e_{ij}$  ( $j=1,2,3,4$ ) refers to degree of membership of No.  $i$  indicator for assessment to remark  $j$  [10];  $e_{i1}, e_{i2}, e_{i3}, e_{i4}$  respectively stand for answer of number of expert assessing excellent, good, medium and poor on indicator for assessment dividing the total amount of expert.

**3.4. Comprehensive Assessment**

When carrying out teaching quality assessment, assessment shall be carried out on each secondary indicator, and assessment matrix of primary indicator according to the weight G of each secondary indicator, that is,

$$B = G^T \times M \tag{11}$$

At last, the final comprehensive assessment results can be obtained from the weight of each primary indicator and score of indicator,

$$S = V \times W \tag{12}$$

**3.5 Teaching Quality Assessment Standard**

Teaching quality assessment can be expressed as below:

$$f = S \cdot X^T \tag{13}$$

In the formula, X stands for score vector corresponding with assessment set, S refers to weight vector and assessment standards are indicated in Table 4.

**Table 4.** Teaching Quality Assessment Standard

Score Y	Grade	Score of Assessment
90	Excellent	>85
75	Good	(75~84)
60	Medium	(60~74)
50	Poor	<40

**4. Application and Result Analysis**

**4.1. Data Source**

In order to explore the effectiveness of fuzzy analytical hierarchy process in classroom teaching quality assessment, and find rules between assessment grade and assessment indicator to figure out the effect of these rules on teaching, we randomly select data of classroom teaching quality assessment of one teacher participating Competition of Young Teachers Class in 2014 to verify, so as to find rules between the assessment of students and teaching quality grade of teacher.

4.2. Calculation of Assessment Indicator Weight

In order to get more accurate assessment results, we divide the assessments of supervisors and teachers and the students' assessment of course learning, so as to obtain the judgment matrix between each two of teachers' teaching quality and weight, as shown in Table 5.

Table 5. Judgment Matrix between Each Two Teachers' Teaching Qualities

A	B1	B2	B3	B4	w <sub>i</sub>	λ <sub>max</sub>	CR
B1	1	1	3	4	0.38	4.02071	0.0078
B2	1	1	3	4	0.38		
B3	1/3	1/3	1	2	0.14		
B4	1/4	1/4	1/2	1	0.01		

Similarly, we can also get weight of each indicator under assessment  $W_{B1}=(0.5,0.5)$ ,  $W_{B2}=(0.4, 0.4, 0.2)$ ,  $W_{B3}=(0.2, 0.2, 0.2, 0.2, 0.2)$  and  $W_{B4}=(0.4, 0.3, 0.3)$ .

4.3. Establishment of Fuzzy Assessment Matrix of Teaching Quality

Based on the established teaching quality assessment indicatory system, we shall establish fuzzy assessment matrix as shown in Table 6.

Table 6. Fuzzy Assessment of Teaching Quality

Judgment Factor	Indicator	Teaching Quality Assessment Grade				$W_{ij}$	$W_i$
		Excellent	Good	Medium	Poor		
B <sub>1</sub>	C <sub>11</sub>	0.7	0.2	0.1	0	0.5	0.125
B <sub>1</sub>	C <sub>12</sub>	0.6	0.4	0.1	0	0.5	
B <sub>2</sub>	R <sub>21</sub>	0.5	0.5	0	0	0.4	0.375
B <sub>2</sub>	R <sub>22</sub>	0.6	0.2	0.1	0.1	0.4	
B <sub>2</sub>	R <sub>23</sub>	0.3	0.4	0.2	0.1	0.2	
B <sub>3</sub>	R <sub>31</sub>	0.5	0.2	0.2	0.1	0.2	0.375
B <sub>3</sub>	R <sub>32</sub>	0.5	0.4	0	0.1	0.2	
B <sub>3</sub>	R <sub>33</sub>	0.6	0.3	0.1	0	0.2	
B <sub>3</sub>	R <sub>34</sub>	0.5	0.4	0.1	0	0.2	
B <sub>3</sub>	R <sub>35</sub>	0.6	0.2	0.1	0.1	0.2	
B <sub>4</sub>	R <sub>41</sub>	0.6	0.3	0.1	0	0.4	0.125
B <sub>4</sub>	R <sub>42</sub>	0.5	0.2	0.2	0.1	0.3	
B <sub>4</sub>	R <sub>43</sub>	0.7	0.3	0	0	0.3	

The factor assessment matrix Bi of each indicator under assessment through disposal by Formula (11) is as below: B1=(0.65, 0.3, 0.1, 0), B2=(0.5, 0.36, 0.1, 0.06), B3=(0.54, 0.3, 0.1, 0.06) and B4=(0.6, 0.27, 0.1, 0.03).

Result set of fuzzy comprehensive assessment is  $S = V \times W = (0.546, 0.319, 0.093, 0.049)$ , so the results of this teacher's teaching quality assessment is  $f = S \cdot X^T = (0.546, 0.319, 0.093, 0.049) \times (90, 75, 60, 50)T = 81.056$ .

In order to explain the effectiveness and objectivity of fuzzy analytical hierarchy process method on teacher's teaching quality, we take single factor assessment method as control method, and the two kinds of assessment results and actual condition are indicated as Figure 1.

It can be concluded from Figure 2 that teaching quality assessment by using fuzzy analytical hierarchy process method is consistent with the actual assessment grade of the teacher (actual value is 81). In the meantime, it can be seen from Table 4 as comparison that this teacher's teaching quality grade is good. According to the maximum membership principle, the indicator under assessment of teaching effect during assessment occupies the largest proportion. Hence, it can be seen that the teachers achieving good teaching effect will generally get higher grade in all classes, which is consistent with the practical situation in our university. However, when using single factor assessment, this teacher's teaching quality only achieves 70.5, at medium grade. Since the single factor assessment method can't comprehensively analyze each indicator under assessment, the score of assessment on this teacher is lower by a grade than the actual value, so as to make the results of assessment is not so objective and fair, and affect the initiative of this teacher.

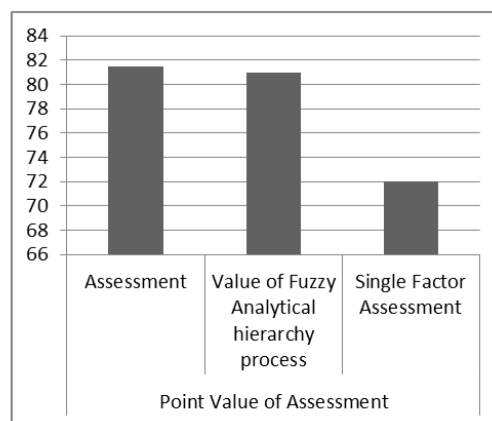


Figure 2. Comparisons of Assessment Results

Conclusions

Assessing teachers' teaching quality by using fuzzy analytical hierarchy process method can combine experience and knowledge of many experts, so as to ensure the objectivity, fairness and accuracy. According to the fuzzy grading of teaching quality based on statistical data, the fuzzy membership func-

tion of teaching quality assessment is established in this article. Comprehensive weight is adopted on weight of factor, so as to fully consider the objective attributes of each assessment indicator according to practical situation, which has good operability and practicability. It can be seen from the process of assessment that teacher must improve teaching effect if he/she wants to improve teaching grade, and shall make the students truly obtain the knowledge taught by the teacher, and effectively improve the quality and ability of students.

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