

## Research on the Classroom Teaching Quality Evaluation in Higher Education via Fuzzy Analytic Hierarchy Process

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**Abstract.** Based on the analysis of actual situation of classroom teaching in higher education from the perspectives of teaching organization, teaching content, teaching skill and teaching effect, this paper constructs the evaluation indicator system and corresponding fuzzy evaluation model of classroom teaching quality in higher education via fuzzy analytic hierarchy process (FAHP). One can use the indicator system and evaluation model to evaluate the quality of classroom teaching. The evaluation steps of teaching quality are elaborated in detail. Moreover, the effectiveness and feasibility of evaluation method proposed in this paper are explicitly proved through the practical example. The results show that this evaluation method will play an important role in promoting the development of higher education.

### Introduction

The higher education of China at the beginning of the 21st century has developed rapidly, and the scale of higher education has been pushed to a new historical high point. Meanwhile, the expansion scale of higher education and the resulting decline of education quality of are attracting more and more attention, and the decline in education quality caused by scale efficiency is very obvious. Hence, the educational and academic fields have put forward a series of teaching reform project to improve the teaching quality of higher education.

Classroom teaching, which is usually considered as the most important teaching form in some universities, is the core component of higher education. Therefore, it is a useful method to improve the overall quality of higher education in the universities by the way of raising the classroom teaching quality [1][2]. Hence, the classroom teaching evaluation plays a very significant role in higher education, and the evaluation is an effective method to improve the quality of classroom teaching, to guide the teachers for forming correct educational ideas, to reflect on their teaching behavior, to form the benign interaction between teachers with students, and to cultivate the innovative spirit of students. Due to its applications in the realm of higher education, a growing number of theoretical and experimental progresses have been made in this domain of the evaluation of classroom teaching quality. For the English teaching, Huang discussed the corresponding evaluation indicator system [3]. Wang proposed a universal evaluation indicator system in the university classroom instruction. Based on the flipped classroom [4], Zhang et al explored the basic connotation of flipped classroom evaluation via the special evaluation system and evaluation criterion[5]. Tang et al put forward the idea of development quality into the category of higher education evaluation, and discussed how to construct the quality evaluation system of higher education development [6]. Tian et al presented a method for evaluating the classroom teaching level of public foreign language teachers by using of analytic hierarchy process, and tested the feasibility of the method through practical examples [7]. Although lots of scholars in various fields have achieved series of research results in the evaluation of classroom teaching quality, many important and open subjects need to be taken into account for the classroom teaching quality evaluation.

In order to overcome the difficulty of data acquisition in the process of classroom teaching quality evaluation in higher education, and take advantage of the subjective evaluation function of the evaluator, this paper will utilize the method of fuzzy analytic hierarchy process to construct the evaluation indicator system of classroom teaching quality in higher education, and establish the corresponding fuzzy evaluation model of classroom teaching quality on the basis of analyzing the actual situation of classroom teaching in higher education. The effectiveness and feasibility of the proposed evaluation method are verified by the practical example. The results prove that our method is useful for the implementation of classroom teaching in universities to improve the efficiency and quality of classroom teaching.

## Evaluation Indicator System of Classroom Teaching Quality

Nowadays, governments, enterprises, organizations and colleges all attaches great importance to improve the quality of matter, it is the same as the field of higher education. By using of scientific methods to evaluate the classroom teaching quality of higher education, we can provide theoretical and practical basis for formulating strategies to improve the teaching quality. Therefore, classroom teaching quality evaluation has become an important part of higher education. In the process of quality evaluation, there are lots of uncertainties, meanwhile, it is difficult to obtain the evaluation data. In order to overcome these difficulties, this paper would introduce the fuzzy analytic hierarchy process (FAHP) into the classroom teaching quality evaluation of higher education.

**Evaluation Indicator Architecture.** Based on the characteristics of classroom teaching in higher education and the principle of selecting indicators in the method of fuzzy analytic hierarchy process, this paper constructs a three-level evaluation indicator system of classroom teaching quality in higher education. The first level is the overall evaluation objective, and this indicator is the classroom teaching quality. The second level contains four sub-items, which are teaching organization, teaching content, teaching skill and teaching effect. Meantime, each sub-item involves a number of indicators. The specific structure of the evaluation indicator system of classroom teaching quality is shown in Figure 1.

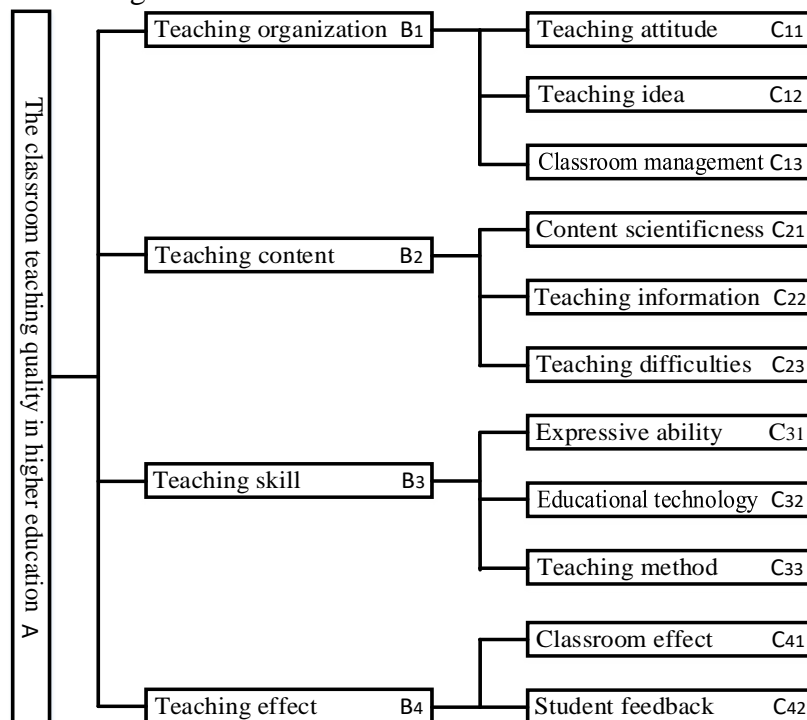


Figure 1. The indicator system of classroom teaching quality assessment in higher education

**Definition of Evaluation Indicators.** In the system structure of evaluation indicators for classroom teaching quality of higher education, the overall evaluation objective of classroom teaching quality is denoted as  $A$ , the second level indicators (teaching organization, teaching

content, teaching skill, teaching effect) are recorded as  $B_i (i=1,2,3,4)$ , respectively. The third level indicators are described as  $C_{ij} (i=1,2,3,4; j=1,2,3)$ , which presents the  $j$ -th element in the  $i$ -th second level indicator. The concrete meanings of classroom teaching quality evaluation indicators are as follows:

(1) Teaching organization  $B_1$  includes three evaluation indicators, which are teaching attitude  $C_{11}$ , teaching idea  $C_{12}$  and classroom management  $C_{13}$ . One can use teaching attitude  $C_{11}$  to examine whether teaching documents are complete, whether teaching plans and lecture notes are standardized, whether the teachers are dignified and full of spirit. Teaching idea  $C_{12}$  reflect the thinking clarity of teachers and the organization of teaching content in the process of classroom teaching. Classroom management  $C_{13}$  is used to characterize whether there are records of absent students in teaching, whether there is the management of improper behavior of students, and whether the teaching organization is in order.

(2) Teaching content  $B_2$  includes three evaluation indicators, content scientificness  $C_{21}$ , teaching information  $C_{22}$  and teaching difficulties  $C_{23}$ . Classroom teaching content should achieve the requirements of the syllabus, the content should be accurate, and the relevant latest achievements can be introduced appropriately. These issues are characterized by the content scientificness  $C_{21}$ . The amount of teaching information  $C_{22}$  mainly evaluates the capacity of classroom teaching knowledge, and assess whether the teaching content  $C_{22}$  is corresponding with the knowledge points. Every lesson has the relative difficulties. The key contents should be explained carefully, and the difficult contents should be analyzed carefully. These points are represented by the indicator of teaching difficulties  $C_{23}$ .

(3) Teaching skill  $B_3$  includes three evaluation indicators, which are expressive ability  $C_{31}$ , educational technology  $C_{32}$  and teaching method  $C_{33}$ . For the classroom teaching, the language of teachers need to be concise, the speak speed would be moderate, and the body language should be used appropriately. The language and body expression ability  $C_{31}$  are of great significance for classroom teaching. Modern classroom teaching is no more *blackboard plus chalk* in the traditional teaching mode. Multimedia teaching method has shown strong advantages in simplifying teaching steps and expanding teaching content. Therefore, the ability to use educational technology  $C_{32}$  is very important. Teaching method  $C_{33}$  mainly inspects whether the appropriate mean is adopted to inspire students based on the teaching content in classroom teaching.

(4) Teaching effect  $B_4$  includes two evaluation indicators, classroom effect  $C_{41}$  and student feedback  $C_{42}$ . The students are the main part of classroom teaching. The proper organization of teaching and reasonable arrangement of teaching content can help the students concentrate on listening lesson to obtain nice teaching effect. This part is mainly described by classroom effect  $C_{41}$ . The fundamental goal of education is to enable the students to receive knowledge, and the knowledge degree of students can be reflected by in-class tests, student homework, test scores, etc. The above content is represented by student feedback indicators  $C_{42}$ .

### Determination the Weight Of Indicators

Table 1 Construction of indicator discrimination matrix

	indicator 1	indicator 2	...	indicator $n$
indicator 1	$a_{11}$	$a_{12}$	...	$a_{1n}$
indicator 2	$a_{21}$	$a_{22}$	...	$a_{2n}$
...	...	...	...	...
indicator $n$	$a_{n1}$	$a_{n2}$	...	$a_{nn}$

Note:  $a_{ij} \in \{1,2,3,4,5,6,7,8,9,1/2,1/3,1/4,1/5,1/6,1/7,1/8,1/9\}$  and  $a_{ji} = 1 / a_{ij}$ .

In the indicator system of classroom teaching quality evaluation for higher education, the second

and third layers contain many indicators. The impact of the same kind of indicators in terms of the upper indicators may be different. The relative weight of evaluation indicators can be quantified by using of the analytic hierarchy process. In this paper, Satty scaling method of 1-9 grades shown in Table 1 is used to determine the corresponding weight of indicators. The discrimination matrix of indicators can be obtained through Satty scaling method.

After obtaining the corresponding indicator discrimination matrix, the relative weight value of indicators can be obtained based on the calculation principle of analytic hierarchy process by the sum-product method, which could be described as

$$w_i = \frac{\sum_{j=1}^n (a_{ij} / \sum_{i=1}^n a_{ij})}{\sum_{i=1}^n [\sum_{j=1}^n (a_{ij} / \sum_{i=1}^n a_{ij})]} \quad i = 1, 2, \dots, n \quad (1)$$

### Classroom Teaching Quality Assessment Model

In the process of evaluating the classroom teaching quality of higher education based on fuzzy analytic hierarchy process (FAHP), five processes are needed: constructing the evaluation indicator set, establishing the evaluation comment set, calculating the indicator weight, determining the fuzzy membership degree of indicators and performing the comprehensive evaluation. The concrete processes for evaluating the classroom teaching quality can be elaborated as follow:

**Step 1** The system structure of evaluation indicators of classroom teaching quality in higher education has been given in Section 2. This system structure includes one overall evaluation target indicator, four secondary evaluation indicators and eleven tertiary evaluation indicators. The membership relationship between these indicators is shown in Figure 1.

**Step 2** Based on the general practice of classroom teaching quality evaluation in higher education, this paper chooses four levels ‘excellent, good, medium and poor’ to form the comment set. Suppose that the evaluation of teaching attitude is excellent 66%, good 16%, medium 14% and poor 4%, thus the corresponding comment can be expressed as  $p(C_{11}) = [p_1, p_2, p_3, p_4] = [0.66, 0.16, 0.14, 0.04]$ , here  $\sum_{i=1}^4 p_i = 1$ .

**Step 3** According to the content of Chapter 2.3 of this paper, the indicator discrimination matrix can be obtained by using of the Satty scale method of 1-9 grades, then the indicator weight could be calculated based on Eq. (1). In view of the three-level indicator system proposed in this paper, it is necessary to calculate the weights  $\{W(A), W(B_1), W(B_2), W(B_3), W(B_4)\}$  of target layer and criterion layers.

**Step 4** Based on the comment set described in Step 2, one can evaluate the third-level indicators in the system structure of evaluation indicators by means of some methods, for instance, document review, expert lectures and questionnaires, and construct the relative fuzzy matrix of second-level indicators according to the indicator relationship.

$$\begin{aligned} p(B_1) &= \begin{bmatrix} 0.74 & 0.13 & 0.10 & 0.03 \\ 0.66 & 0.16 & 0.12 & 0.06 \\ 0.54 & 0.20 & 0.16 & 0.10 \end{bmatrix}, & p(B_2) &= \begin{bmatrix} 0.70 & 0.16 & 0.09 & 0.05 \\ 0.56 & 0.26 & 0.16 & 0.02 \\ 0.65 & 0.22 & 0.10 & 0.03 \end{bmatrix} \\ p(B_3) &= \begin{bmatrix} 0.64 & 0.23 & 0.10 & 0.03 \\ 0.60 & 0.20 & 0.15 & 0.05 \\ 0.55 & 0.18 & 0.14 & 0.13 \end{bmatrix}, & p(B_4) &= \begin{bmatrix} 0.76 & 0.16 & 0.05 & 0.03 \\ 0.66 & 0.24 & 0.09 & 0.01 \end{bmatrix} \end{aligned} \quad (2)$$

**Step 5** According to the evaluation criteria of fuzzy analytic hierarchy process and the indicator weight set  $\{W(B_1), W(B_2), W(B_3), W(B_4)\}$  with the relative fuzzy matrix  $\{p(B_1), p(B_2), p(B_3), p(B_4)\}$ . The evaluation results of secondary indicators can be obtained based on the follow formulas:

$$\tilde{p}(B_m) = w(B_m) * p(B_m) \quad m = 1, 2, 3, 4 \quad (3)$$

The corresponding fuzzy matrix  $p(A)$  of overall evaluation objective (classroom teaching quality) is composed of the above evaluation values, and  $p(A)$  can be expressed as  $[\tilde{p}(B_1), \tilde{p}(B_2), \tilde{p}(B_3), \tilde{p}(B_4)]^T$ . Based on the weight  $w(A)$  of target level indicators and the corresponding fuzzy matrix  $p(A)$ , the final evaluation result of classroom teaching quality in higher education can be expressed as follow:

$$\tilde{p}(A) = w(A) * p(A) \quad (4)$$

## Application Case

This chapter would take a practical classroom teaching case of *The Outline of Chinese Modern History* in GKD University as the research object. Based on the evaluation indicator system of classroom teaching quality of higher education proposed in Section 2 and fuzzy evaluation model constructed in Section 3, this paper would evaluates the quality of classroom teaching by using of fuzzy analytic hierarchy process. The specific processes are presented as follows:

**Step 1** Construct the evaluation indicator set of classroom teaching quality in higher education. Actually, this set is composed of all evaluation indicators in the system of classroom teaching quality assessment for higher education.

**Step 2** Establish the comment set. According to the usual practice of classroom teaching quality evaluation, this paper chooses ‘excellent, good, medium and poor’ as the comment set of classroom teaching quality evaluation.

**Step 3** Calculate the indicator weight. By means of the methods of expert consultation and document review, the discrimination matrix corresponding to the first-level and second-level indicators are obtained as follow:

$$\begin{aligned} D(B_1) &= \begin{bmatrix} 1 & 1/2 & 3 \\ 2 & 1 & 1/3 \\ 1/3 & 3 & 1 \end{bmatrix}, \quad D(B_2) = \begin{bmatrix} 1 & 2 & 1/4 \\ 1/2 & 1 & 3 \\ 4 & 1/3 & 1 \end{bmatrix}, \quad D(B_3) = \begin{bmatrix} 1 & 1/3 & 1/2 \\ 3 & 1 & 1 \\ 2 & 1 & 1 \end{bmatrix} \\ D(B_4) &= \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}, \quad D(A) = \begin{bmatrix} 1 & 2 & 3 & 1/4 \\ 1/2 & 1 & 3 & 2 \\ 1/3 & 1/3 & 1 & 1/3 \\ 4 & 1/2 & 3 & 1 \end{bmatrix} \end{aligned} \quad (5)$$

According to the sum-product method shown as Eq. (2) of analytic hierarchy process, the relative indicator weights of the first-level and second-level can be calculated and written as follow:

$$\begin{aligned} w(B_1) &= [0.53, 0.25, 0.22] & w(B_2) &= [0.48, 0.21, 0.31] \\ w(B_3) &= [0.40, 0.21, 0.39] & w(B_4) &= [0.50, 0.50] \\ w(A) &= [0.26, 0.28, 0.36, 0.10] \end{aligned} \quad (6)$$

**Step 4** Obtain the fuzzy membership matrix  $\{p(B_1), p(B_2), p(B_3), p(B_4)\}$  of the secondary indicator based on the conclusion of Section 3.

**Step 5** We could obtain  $\{\tilde{p}(B_1), \tilde{p}(B_2), \tilde{p}(B_3), \tilde{p}(B_4)\}$  based on the second-level indicator evaluation formula described as Eq. (3), then  $p(A)$  can be determined immediately. Finally, the overall evaluation value of classroom teaching quality through Eq. (4) can be obtained:

$$\tilde{p}(A) = w(A) * p(A) = [0.76, 0.24, 0.06, 0.04] \quad (7)$$

Based on the above steps of classroom teaching quality evaluation, we can know that the result of classroom teaching quality evaluation of *The Outline of Chinese Modern History* is excellent.

## Summary

Classroom teaching is an important part for higher education. The classroom teaching quality is of great significance for overall education quality. Because of that the evaluation of classroom teaching quality can provide theoretical and practical basis for corresponding promotion strategies, the classroom teaching evaluation plays an important role in higher education. According to the specific situation of classroom teaching of higher education from the aspects of teaching organization, teaching content, teaching skill and teaching effect, this paper constructs the evaluation indicator system and establishes the relative fuzzy evaluation model of classroom teaching quality in higher education via fuzzy analytic hierarchy process (FAHP). Furthermore, the concrete evaluation steps of classroom teaching quality are presented in detail. The effectiveness and feasibility of classroom teaching quality assessment method are verified by using of actual evaluation case. The relevant research results of classroom teaching quality evaluation by using of fuzzy analytic hierarchy process can be further extended to similar evaluation works. This method has some reference value for evaluation research in the field of higher education.

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## References

- [1] Li J and Ouyang RQ. The quality evaluation indicators about classroom teaching in higher education institutions [J]. Heilongjiang Education: Research and Evaluation of Higher Education, 2011 (5):14-15.
- [2] Cai HM and Xu XD. Construction of quality evaluation system of classroom teaching in colleges and universities [J]. Research in Higher Education of Engineering, 2014 (3):177-180.
- [3] Huang WP. On evaluation indicator system of college english teaching [J]. Journal of Guangxi University for Nationalities: Philosophy and Social Sciences, 2007 (2): 189-191.
- [4] Wang SZ. A research on constructing evaluation indicator system in university classroom instruction [J]. Journal of Jiangnan University: Educational Science Edition, 2009 (29): 50-53.
- [5] Zhang JX and Zhu L. Research on assessment of flipped classroom in colleges and universities from CDIO perspective [J]. Journal of Heilongjiang College of Education, 2017 (36): 30-33.
- [6] Tang HS and Ye HF. Development quality: A new orientation of higher education assessment [J]. Journal of Linyi University, 2011 (33): 47-51.
- [7] Tian Y and Wang CR. A method of quantitative evaluation of foreign language teaching level based on analytic hierarchy process [J]. Journal of Inner Mongolia Normal University: Educational Science Edition, 2014 (43): 118-12.