# Research on the Evaluation Indicator System and Evaluation Method of the Effectiveness of Cased-Based Teaching

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**Abstract.** Cased-based teaching is a kind of teaching approach with practice and interaction. It plays an important role in grasping knowledge and fostering comprehensive ability for students, and is extensively used in the education of undergraduate and MBA. In this paper, we review present situation of the research on the evaluation of cased-based teaching, and put forward a set of comprehensive evaluation indicator system about the effectiveness of cased-based teaching, which includes indicators reflecting both the process and the result of case-based teaching. Finally, Analytic Hierarchy Process is used to determine the weights of indicators and the method of multilevel fuzzy comprehensive evaluation is used to compute the comprehensive evaluation score of the effectiveness of cased-based teaching. The comprehensive evaluation indicator system and evaluation method provide a standard and an approach for examining the effectiveness of cased-based teaching.

**Keywords:** Cased-Based Teaching · Indicator System · Analytic Hierarchy Process (AHP) · Fuzzy Comprehensive Evaluation

## 1 Introduction

Case-based teaching is a relatively new approach to teaching basic sciences. Zhao Shuming argued that, in comparison with traditional teaching method of lectures, the method of case-based teaching can arouse the enthusiasm of learning and improve the effectiveness of teaching [1]. The evaluation of the effectiveness of cased-based teaching is the premise of understanding and supervising cased-based teaching and stimulating teachers. Through the evaluation of the effectiveness of cased-based teaching, we can find the issues in the process of cased-based teaching and guide this process, and thereby raise the quality of cased-based teaching.

Based on the students' qualitative and quantitative feedback, as well as peer evaluation, Davide Giacalone discussed the effectiveness of case-based teaching in growing student participation and promoting a more active way of learning. The role of Audience Response Systems in facilitating class discussion and providing a real-time assessment

of the teaching effectiveness was also explored [2]. Farrukh Majeed compared the effectiveness of didactic and case-based teaching of physiology among nursing students, and found interactive case discussions are more enjoyable and educationally stimulating than lectures. He maintained that case-based teaching should be widely used in the basic sciences courses in order to increase the appeal [3].

In recent years, in the manner of grouping the students, scholars have compared different feedback of the students on case-based teaching and traditional teaching in major courses of medicine. Taking cardiovascular physiology module for clinical pharmacy students as an example, Ahmed A. Alsunni and Nazish Rafique compared the learning performance and exam achievement of case-based teaching and traditional didactic teaching, showing that case-based teaching enhanced logical thinking, facilitated active participation in the classroom, and improved student performance on exams [4].

From three dimensions, i.e., teaching content, teaching method and teaching attitude, Wang Jichao, Li Junnan discussed the factors that influenced the satisfaction of case-based teaching [6]. Liu Youping, Zhang Lijuan explored a new teaching mode integrating online and offline resources, and conducted questionnaire survey on the effectiveness of case-based teaching in the course of project management. Some suggestions on the reform of case-based teaching mode were given [6]. Mi Lingyun *et al.* used the structural equation model to conduct an empirical study on the main factors influencing the teaching effect of MBA cases and the mechanism of their actions, from class participation, pre-class preparation, learning styles, case studying attitude, case quality perception, teacher comments, and teaching environment [7] Liu Yanwen and Guan Linfang set up an evaluation system of case teaching effectiveness by means of cluster analysis and dimension reduction with principal component analysis and AHP, determined the weights of the indicators based on entropy, and established a comprehensive evaluation model [8].

In summary, indicators of teaching evaluation in domestic research place emphasis on ordinary teaching mode, while little research has been implemented on indicator system about the effectiveness of cased-based teaching. At present, most researches on the effectiveness of cased-based teaching aim at only certain course or cased-based teaching in MBA, and the design of some indicator systems is not reasonable. Therefore, there is no universal indicator system about the comprehensive evaluation of cased-based teaching. It is necessary to set up an indicator system about the evaluation of cased-based teaching according to the features of the process of cased-based teaching. Thus, an objective, fair and scientific evaluation on the quality of cased-based teaching can be achieved, and corresponding methods to solve issues in the process of cased-based teaching can be explored. In order to assess the effectiveness of cased-based teaching objectively and scientifically, two critical problems are to be solved. (1) To choose reasonable evaluation indicators and construct an indicator system about the evaluation of cased-based teaching, and give weight to each indicator according to actual situation. (2) To choose appropriate evaluation method and determine the score of the objective to be assessed on every indicator. Then we use certain mathematical model to aggregate the indicator values and the weight of indicators into a comprehensive evaluation value.

## 2  Construction of the Evaluation Indicator System for Examining the Effectiveness of Cased-Based Teaching

### 2.1  The Principles of Designing an Indicator System for Teaching Evaluation

The design of an indicator system to evaluate cased-based teaching should satisfy the principles suitable to general evaluation indicator system. (1) every indicator should be a nominal phrase, and as short as possible and easy to understand. (2) the phrase expressing an indicator should not include the evaluative word, otherwise, this indicator would lose the function of evaluation. (3) The indicators must be measurable and can reflect the common attribute of the objectives to be evaluated, so comparison of the objectives is for use. (4) All indicators of the indicator system should be independence, especially the indicators in the same level can't overlap. (5) The whole indicator system should be complete so as to reflect main features of the objectives to be evaluated.

Beside the above principles, the design of an indicator system to evaluate cased-based teaching should meet its specific needs. First, the design of an indicator system to evaluate cased-based teaching should be based on the goal of the evaluation of cased-based teaching. In other words, only those evaluation indicators reflecting the issues in the process of cased-based teaching can guide the process of cased-based teaching. Second, evaluation indicators for cased-based teaching must embody localization characteristics and should not copy from the standard of western countries, instead, we should consider the ability, level of teachers and students participating in cased-based teaching [6]. Third, evaluation indicators for cased-based teaching should be feasible, i.e., reflecting the actual level of education in our country.

### 2.2  The Comprehensive Evaluation Indicator System for Examining the Effectiveness of Cased-Based Teaching

Cased-based teaching is a process of interaction, which involves three aspects, i.e., the teacher, the students and the case. Among them, an elaborately chosen case is the base of cased-based teaching. The active preparation of the students before a course and the discussion and speech in the class are the primary factors, and effective organization of the teacher is the guarantee of the success of cased-based teaching. Hence, the case preparation, case discussion and case comment are three parts of cased-based teaching. The comprehensive evaluation indicator system given in this paper for examining the effectiveness of cased-based teaching is showed in Table 1.

In some indicators in the second level, we can design indicators in third level. For one example, for the situation of drawing up the plan of cased-based teaching, one can design indicators in the third level from the following aspects: the goal of cased-based teaching, the conception of ways of cased-based teaching, and the assignment of discussion issues. For another, for the evaluation of training the students' ability to analyze and solve problems, the ability to find a problem, the innovation and feasibility of the solution, and the depth and breadth of problem analysis are proper indicators as the third level.

**Table 1.** The evaluation indicator system reflecting the effectiveness of cased-based teaching

| | | |
|---|---|---|
| The evaluation of the effectiveness of cased-based teaching (A) | Preparation of the case (B₁) | Situation of drawing up the plan of cased-based teaching (C₁₁) |
| | | Matching degree of the case content with the course content (C₁₂) |
| | | Combination of the case content with reality (C₁₃) |
| | | Situation of the case content reflecting hot issues and issues of widespread concern in enterprises or other organizations (C₁₄) |
| | Discussion of the case (B₂) | Effectiveness of organizing case discussion (C₂₁) |
| | | Situation of using advanced teaching means by the teacher (C₂₂) |
| | | Situation of the students' speech and question (C₂₃) |
| | | Situation of training the students' ability to analyze and solve problems (C₂₄) |
| | Comment on the case (B₃) | Rationality of comments of the teacher (C₃₁) |
| | | Enlightening of comments of the teacher (C₃₂) |
| | | The degree of perfection of the supplement to a student's speech (C₃₃) |

# 3   To Determine the Weights of the Evaluation Indicators on the Effectiveness of Cased-Based Teaching

The evaluation of the effectiveness of cased-based teaching is a problem with comprehensiveness and multi-factors, and there is a complex hierarchical structure among evaluation indicators, while different hierarchies are related to each other. In this paper, Analytic Hierarchy Process (AHP) is used to determine the weights of indicators. The largest characteristic root and corresponding eigenvector are calculated by Matlab, so the process is simple and easy to operate.

In this paper, five experts are invited to provide judgement matrices about the relative importance of evaluation indicators on the effectiveness of cased-based teaching.

The judgement matrices A-B about the evaluation of the effectiveness of cased-based teaching in the first level of indicators are as follows:

$$A^1 = \begin{bmatrix} 1 & 1/2 & 2 \\ 2 & 1 & 4 \\ 1/2 & 1/4 & 1 \end{bmatrix}, A^2 = \begin{bmatrix} 1 & 1/3 & 5 \\ 3 & 1 & 7 \\ 1/5 & 1/7 & 1 \end{bmatrix}, A^3 = \begin{bmatrix} 1 & 1/3 & 3 \\ 3 & 1 & 6 \\ 1/3 & 1/6 & 1 \end{bmatrix},$$

$$A^4 = \begin{bmatrix} 1 & 1/2 & 2 \\ 2 & 1 & 4 \\ 1/2 & 1/4 & 1 \end{bmatrix}, A^5 = \begin{bmatrix} 1 & 1/3 & 2 \\ 3 & 1 & 5 \\ 1/2 & 1/5 & 1 \end{bmatrix}.$$

where the superscripts of A, i.e., 1, 2, ......, 5, represent expert 1, expert 2, ......, expert 5, similarly hereinafter.

The judgement matrices $B_1$-C about the evaluation of the effectiveness of cased-based teaching in the second level of indicators are as follows:

$$B_1^1 = \begin{bmatrix} 1 & 1/5 & 1/7 & 1/5 \\ 5 & 1 & 1/3 & 1 \\ 7 & 3 & 1 & 3 \\ 5 & 1 & 1/3 & 1 \end{bmatrix}, \ B_1^2 = \begin{bmatrix} 1 & 1/5 & 1/5 & 1/3 \\ 5 & 1 & 1 & 2 \\ 5 & 1 & 1 & 2 \\ 3 & 1 & 1/2 & 1 \end{bmatrix},$$

$$B_1^3 = \begin{bmatrix} 1 & 1/2 & 2 & 1 \\ 2 & 1 & 4 & 2 \\ 1/2 & 1/4 & 1 & 1/3 \\ 1 & 1/2 & 3 & 1 \end{bmatrix}, B_1^4 = \begin{bmatrix} 1 & 1/3 & 2 & 1 \\ 3 & 1 & 5 & 3 \\ 1/2 & 1/5 & 1 & 1/2 \\ 5 & 1/3 & 2 & 1 \end{bmatrix},$$

$$B_1^5 = \begin{bmatrix} 1 & 1/2 & 2 & 1/2 \\ 2 & 1 & 4 & 1 \\ 1/2 & 1/4 & 1 & 1/4 \\ 2 & 1 & 4 & 1 \end{bmatrix};$$

The judgement matrices $B_2$-C about the evaluation of the effectiveness of cased-based teaching in the second level of indicators are as follows:

$$B_2^1 = \begin{bmatrix} 1 & 5 & 1/3 & 1/3 \\ 1/5 & 1 & 1/7 & 1/7 \\ 3 & 7 & 1 & 1 \\ 3 & 7 & 1 & 1 \end{bmatrix}, \ B_2^2 = \begin{bmatrix} 1 & 3 & 1/3 & 1/3 \\ 1/3 & 1 & 1/5 & 1/5 \\ 3 & 5 & 1 & 1 \\ 3 & 5 & 1 & 1 \end{bmatrix},$$

$$B_2^3 = \begin{bmatrix} 1 & 5 & 1/2 & 1/3 \\ 1/5 & 1 & 1/7 & 1/8 \\ 2 & 7 & 1 & 1/2 \\ 3 & 8 & 2 & 1 \end{bmatrix}, \ B_2^4 = \begin{bmatrix} 1 & 5 & 1/3 & 1/3 \\ 1/5 & 1 & 1/8 & 1/8 \\ 3 & 8 & 1 & 1 \\ 3 & 8 & 1 & 1 \end{bmatrix},$$

$$B_2^5 = \begin{bmatrix} 1 & 5 & 1/2 & 1/3 \\ 1/5 & 1 & 1/7 & 1/8 \\ 2 & 7 & 1 & 1/2 \\ 3 & 8 & 2 & 1 \end{bmatrix};$$

The judgement matrices $B_3$-C about the evaluation of the effectiveness of cased-based teaching in the second level of indicators are as follows:

$$B_3^1 = \begin{bmatrix} 1 & 1/3 & 1 \\ 3 & 1 & 3 \\ 1 & 1/3 & 1 \end{bmatrix}, B_3^2 = \begin{bmatrix} 1 & 1/5 & 1/5 \\ 5 & 1 & 1 \\ 5 & 1 & 1 \end{bmatrix}, B_3^3 = \begin{bmatrix} 1 & 1/5 & 1/3 \\ 5 & 1 & 3 \\ 3 & 1/3 & 1 \end{bmatrix},$$

$$B_3^4 = \begin{bmatrix} 1 & 1/4 & 1/4 \\ 4 & 1 & 1 \\ 4 & 1 & 1 \end{bmatrix}, B_3^5 = \begin{bmatrix} 1 & 1/5 & 1/4 \\ 5 & 1 & 2 \\ 4 & 1/2 & 1 \end{bmatrix};$$

Through computation, we know all matrices pass the consistency check.

We use Matlab to get the raking vectors of every five matrices above, and use arithmetic mean to get weight vector of indicators in the first level, i.e., $A = (0.2502, 0.4973, 0.2525)$, and weight vectors of indicators in the first level, i.e., $A_1 = (0.1410, 0.3794, 0.2338, 0.2458)$; $A_2 = (0.1695, 0.0491, 0.3533, 0.4281)$; $A_3 = (0.1208, 0.5411, 0.3381)$.

## 4 An Overall Evaluation on the Effectiveness of Cased-Based Teaching

In this paper, multilevel Fuzzy Comprehensive Evaluation is used to determine the comprehensive evaluation value of effectiveness of cased-based teaching.

### 4.1 The Basic Steps of Fuzzy Comprehensive Evaluation

The method of fuzzy comprehensive evaluation is widely used in fuzzy mathematics, its steps are as follows:

(1) give the set of objectives to be chosen.
(2) To determine the set of indicators or factors.
(3) To construct the set of weights: to give corresponding weights for the indicators in the first level and the second level so as to reflect the relative importance of these indicators. The set of weights in the first level is $A = (a_1, a_2, ..., a_n)$, and the set of weights in the second level is $A_i = (a_{i1}, a_{i2}, ..., a_{ij})(i = 1, 2, ..., n)$.
(4) To determine the set of comment, i.e., $V = (v_1, v_2, \cdots, v_m)$.
(5) To determine the comment matrix, i.e., $R = (r_{ij})_{n \times m}$, where $r_{ij}$ is the degree of membership of each indicator under different grade.
(6) To aggregate the information of indicator weight and comment matrix, then we can get the final evaluation result.

### 4.2 The Application of Fuzzy Comprehensive Evaluation in the Evaluation of the Effectiveness of Cased-Based Teaching

Most of indicators are qualitative, and the involved factors are uncertain or not easy to quantify. Meanwhile, the connotation and extending meaning of some factors are uncertain. The assessment of effectiveness of cased-based teaching is somewhat vague. So, in the process of assessment, we can use fuzzy comprehensive evaluation to get overall and summary understanding, and avoid the absoluteness of the experts' scores.

First, we determine the set of assessment factors according to the evaluation indicator system for examining the effectiveness of cased-based teaching, which is showed in Table 1.

The set of assessment factors in the first level is $U = (B_1, B_2, B_3)$.

The sets of assessment factors in the second level are $U_1 = \{C_{11}, C_{12}, C_{13}, C_{14}\}$, $U_2 = \{C_{21}, C_{22}, C_{23}, C_{24}\}$, $U_3 = \{C_{31}, C_{32}, C_{33}\}$.

In this paper, we divide the grades of the evaluation on the effectiveness of cased-based teaching into five types, i.e., excellent, better, good, medium and bad. In other words, $V = \{v_1, v_2, v_3, v_4, v_5\} = \{\text{excellent, better, good, medium, bad}\}$.

Second, we carry out single factor assessment about the element $B_i$ $(i = 1, 2, 3)$ in U. Focusing on Bi, we determine the degree of membership of objectives belonging to grade $v_j(j = 1, 2, \cdots, 5)$.The set of single factor comment of $B_i$ is $r_i = \{r_{i1}, r_{i2}, \cdots, r_{i5}\}$, which is a fuzzy subset on V. In such way, comment sets of three factors in U constitute an overall comment matrix $R$, which is a fuzzy relation from U to V.

Because the degree of membership is an abstract concept, we propose to assess the teacher who implements case-based teaching by the students and teaching supervisors. Suppose 5% of the evaluators think the teacher is excellent, 25% of them think he/she is better, 40% of them think he/she is good, 20% of them think he/she is medium, and 10% of them think he/she is bad, then we get single factor comment (0.05, 0.25, 0.40, 0.20, 0.10). Similarly, we can carry on single factor comment on other factors. Finally, we obtain the following data:

For $B_1$, we have

$$R_1 = \begin{bmatrix} 0.10 & 0.25 & 0.40 & 0.20 & 0.10 \\ 0.12 & 0.28 & 0.20 & 0.35 & 0.05 \\ 0.18 & 0.14 & 0.26 & 0.32 & 0.10 \\ 0.25 & 0.25 & 0.30 & 0.10 & 0.10 \end{bmatrix}.$$

For $B_2$, we have

$$R_2 = \begin{bmatrix} 0.12 & 0.25 & 0.38 & 0.18 & 0.12 \\ 0.13 & 0.27 & 0.23 & 0.32 & 0.05 \\ 0.15 & 0.17 & 0.25 & 0.33 & 0.10 \\ 0.25 & 0.25 & 0.30 & 0.15 & 0.05 \end{bmatrix}.$$

For $B_3$, we have

$$R_3 = \begin{bmatrix} 0.19 & 0.28 & 0.28 & 0.23 & 0.02 \\ 0.10 & 0.25 & 0.35 & 0.25 & 0.10 \\ 0.17 & 0.15 & 0.26 & 0.32 & 0.10 \end{bmatrix}.$$

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Third, we carry out fuzzy comprehensive evaluation by means of fuzzy transformation on $A_i$ and $R_i$, i.e., $D_i = A_i \cdot R_i = (d_1, d_2, \cdots, d_n)$, where $d_j = \sum_{i=1}^{m} a_i r_{ij}$, j = 1, 2, \ldots, n..

Hence,

$$D_1 = (0.1410, \quad 0.3794, \quad 0.2338, \quad 0.2458) \begin{bmatrix} 0.10 & 0.25 & 0.40 & 0.20 & 0.10 \\ 0.12 & 0.28 & 0.20 & 0.35 & 0.05 \\ 0.18 & 0.14 & 0.26 & 0.32 & 0.10 \\ 0.25 & 0.25 & 0.30 & 0.10 & 0.10 \end{bmatrix}.$$

$= (0.16, 0.24, 0.27, 0.26, 0.08)$.

Similarly, we get $D_2 = (0.19, 0.22, 0.29, 0.23, 0.08)$, $D_3 = (0.13, 0.22, 0.31, 0.27, 0.09)$..

Forth, we carry out comprehensive comment in the second level. Based on the elements $B_1, B_2, B_3$, we use $D_1, D_2, D_3$ to construct their single factor comment matrix.

$$R = \begin{bmatrix} 0.16 & 0.24 & 0.27 & 0.26 & 0.08 \\ 0.19 & 0.22 & 0.29 & 0.23 & 0.08 \\ 0.13 & 0.22 & 0.31 & 0.27 & 0.09 \end{bmatrix}.$$

And then we get the second level comment

$$D = A \cdot R = (0.2502, 0.4973, 0.2525) \begin{bmatrix} 0.16 & 0.24 & 0.27 & 0.26 & 0.08 \\ 0.19 & 0.22 & 0.29 & 0.23 & 0.08 \\ 0.13 & 0.22 & 0.31 & 0.27 & 0.09 \end{bmatrix}$$

$$= (0.16, 0.22, 0.29, 0.25, 0.08)$$

According to the principle of maximal membership, this cased-based teaching is good. However, we can see from $D$ that 33% of the evaluators regard the effectiveness of this cased-based teaching as medium and bad. As conclusion, the effectiveness of this cased-based teaching should be improved.

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