An Integrated Approach for Evaluating Teaching Competence in Colleges and Universities

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Abstract. Personnel competence is of great importance for any organization whereas its evaluation still has not been fully addressed especially in the higher education sector. In this article an integrated approach of analytical hierarchy process (AHP) and grey relational analysis (GRA) is proposed to evaluate teaching competence of teachers in colleges and universities. First, an evaluation framework on teaching competence is developed, which includes four criteria with fourteen sub-criteria. Then, the procedures of AHP and GRA are introduced in setting up a comprehensive evaluation model. In addition, a case study is used to illustrate the effectiveness of this integrated approach. The result shows that AHP-GRA evaluation approach can be applied to evaluate teaching competence of college teachers scientifically and conveniently. The evaluation results can help administrative departments in colleges and universities to improve human resources management practices.

Keywords: college teachers; teaching competence; analytical hierarchy process (AHP); grey relational analysis (GRA).

1. Introduction

Competence has been received more and more attentions from researchers and practitioners over the past few years. In competence-based human resource management, personnel competence has been treated as one of the most important core competences and has increasingly become the source of competitive advantage. Despite the acknowledgment of the importance of personnel competence for any organization, few studies have been conducted in the higher education sector and even fewer studies have been specifically focused on the teaching competence of college teachers. Talents cultivation is the most basic function and is the center task of colleges and universities. As the main force of performing functions, college teachers are the most valuable human resources, and their teaching competences are the critical important antecedents of talents cultivation. Hence, this study attempts to make some contributions by introducing competence theory into human resource management in the higher education sector and exploring the evaluation model and method of teaching competency.

The reminder of this paper is organized as follows. The next section provides a brief review of the relevant literature and develops the framework of teaching competence. The third section presents the procedures of the integrated analytical hierarchy process (AHP) and grey relational analysis (GRA) approach with a case. Finally, we close by providing some discussions and implications.

2. Theoretical Framework of Teaching Competence

Since McClelland put forward the concept of competence, many scholars have defined this concept from their own research perspectives. According to McClelland, competence is the personal features that can lead to expected performance [1]. Similarly, Spencer and Spencer define competence as the basic characteristics of a person which facilitate superior performance in a given situation [2]. In this paper, competence is defined as the underlying traits of an individual and the resulting behavior characteristics which in turn lead to desired performance in specific tasks. Accordingly, this article

decomposes teaching competence of college teachers into four dimensions (criteria): professional attitude competence, curriculum development competence, basic teaching competence and teaching reflection competence. This study applies the nominal group technique combined with the relevant literature to select sub-criteria for each criteria. The framework of teaching competence of college teachers is shown in Table 1.

Table 1 Framework of teaching competence in colleges and universities

Professional attitude competence (PAC)	healthy mental attitude (PAC1)
	spirit of utter devotion (PAC2)
	caring for students (PAC3)
	taking initiative at work (PAC4)
Curriculum development competence (CDC)	drawing frontier knowledge into teaching (CDC1)
	original and updated teaching contents (CDC2)
Basic teaching competence (BTC)	guiding self-regulated learning and discussion (BTC1)
	clear communication and proper expression (BTC2)
	proficient in modern teaching technology (BTC3)
	flexible teaching contents and approaches (BTC4)
	heuristic teaching with active atmosphere (BTC5)
Teaching reflection competence (TRC)	reflecting teaching philosophy, activities and effects (TRC1)
	learning from other's teaching experiences and achievements (TRC2)
	instantly access to feedback information for queries (TRC3)

Of the four criteria, professional attitude belongs to personal traits which is the base of the other three behavior characteristics, namely curriculum development, basic teaching and teaching reflection. Curriculum development competence refers to a college teacher can draw frontier knowledge into teaching, and constantly develop and update teaching content. Basic teaching competence refers to a college teacher can effectively arrange teaching activities and impart specific knowledge and skill to students through proper methods. Teaching reflection competence refers to a college teacher can treat "professional self" and "teaching activities" as the object of consciousness, reflection and improvement.

3. Evaluating Teaching Competence with AHP-GRA Approach

3.1 Integrating AHP with the teaching competence framework

Analytic hierarchy process (AHP) was first introduced by Saaty in the 1970s and afterwards it gained widely acceptance [3, 4]. With AHP method, a complicated system can be converted into a hierarchical system of elements. The hierarchy is constructed in such a way that the overall goal is at the top level, criteria are in the middle level(s), and alternatives at the bottom [5, 6].

AHP provides unique features for criteria weight and subjective evaluations by pairwise comparisons and the 1-9 ratio scale as shown in Table 2 [5, 6]. The AHP method involves the following steps [5-9]:

Step 1: Building the hierarchy framework

Based on the teaching competence framework, a proposed hierarchical structure is constructed as Figure 1. The overall goal is to evaluate the teaching competence (Level 1). Under the overall goal, the second level represents the criteria, including professional attitude competence (PAC), curriculum development competence (CDC), basic teaching competence (BTC), and teaching reflection competence (TRC). Various sets of sub-criteria which are related to the second level criteria are given in the third level.

Table 2 the 1-9 scales for pairwise comparisons in AHP

Level of Importance	Definition	Illustration
1	Equal importance	Criteria i and j are of equal importance
3	Moderate importance	Criteria i is moderately more important than j
5	Strong importance	Criteria i is strongly more important than j
7	Very strong importance	Criteria i is very strongly more important than j
9	Extreme importance	Criteria i is extremely more important than j
2, 4, 6, 8	Intermediate values	The digits 2, 4, 6 and 8 are judgment values between equally, moderately, strongly, very strongly, and extremely.
Reciprocals	Reciprocals for inverse comparison	

Step 2: Pairwise comparison

The pairwise comparison highlights the relative importance of each criteria or sub-criteria. Let $C_1, C_2, \cdots, C_n$ be the set of elements, while v_{ij} represents a judgment on a pair of elements C_i, C_j. An n-by-n matrix V is derived as follows:

$$V = \left[v_{ij} \right] = \begin{bmatrix} 1 & v_{12} & \cdots & v_{1n} \\ 1/v_{12} & 1 & \cdots & v_{2n} \\ \vdots & \vdots & & \vdots \\ 1/v_{1n} & 1/v_{2n} & \cdots & 1 \end{bmatrix} \quad (1)$$

In matrix V, $v_{ii} = 1$, $v_{ji} = 1/v_{ij}$, and $i, j = 1, 2, \cdots, n$. The relations among weights and judgments are simply given by $w_i / w_j = v_{ij} \quad (i, j = 1, 2, \cdots n)$. The pairwise comparison of the four criteria was done with respect to teaching competence. A group decision making approach was employed in this study. Two administrative personnel and three teachers from one college were invited to be the decision-makers. The individual judgments were then summarized and discussed to help achieve consensus. As similar to the pairwise comparison of criteria, the pairwise comparison of the sub-criteria was also done.

Step 3: Consistency test

Having done all the pairwise comparisons, the degree of consistency can be estimated by consistency ratio (CR) that is mathematically expressed as:

$$\lambda_{\max} = \sum_{j=1}^{n} v_{ij} \frac{w_j}{w_i} \quad (2)$$

$$CI = (\lambda_{\max} - n) / (n-1) \quad (3)$$

$$CR = CI / RI \quad (4)$$

In formula 3, n denotes number of criteria or attributes and $\lambda_{\max}$ denotes maximum eigenvalue of the matrix of pairwise comparisons. In formula 4, CI denotes consistency index and RI denotes the average consistency index. If $CR < 0.1$, the estimate is accepted. The CR of the comparison matrices for the criteria and the sub-criteria are all smaller than "0.1", indicating "consistency." Furthermore, the CR of the aggregate matrix is also below "0.1", again indicating "consistency."

Step 4: Calculation of weights

In this step, the local weights and global weights of elements were calculated. The local weights are the relative value of the element with respect to the particular element which is placed at its immediate above hierarchy level, and these priorities can be identified by calculating the eigenvalues and eigenvectors. Eigenvector X can be calculated by the following formula.

$$(V - \lambda_{\max} X) = 0 \quad (5)$$

When the vector X is normalized, it becomes the vector of priorities of elements of one level with respect to the element in the upper level (see Figure 1). After calculating the relative value, the global weight of each sub-criteria is calculated by multiplying its local priority weight with its corresponding weight along the hierarchy (see Table 3).

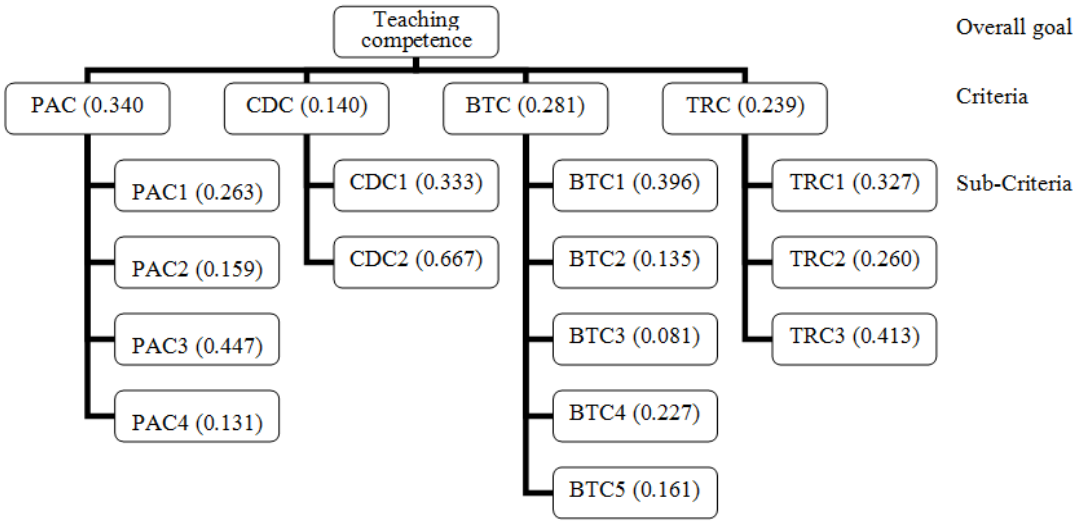

Fig. 1 Hierarchical structure of teaching competence with weights

Table 3 Weights for criteria and sub-criteria

Criteria	Criteria weights	Sub-criteria	Sub-criteria weights				Overall weights	Rank
PAC	0.340	PAC1	0.263	0	0	0	0.089	5
		PAC2	0.159	0	0	0	0.054	9
		PAC3	0.447	0	0	0	0.152	1
		PAC4	0.131	0	0	0	0.045	11
CDC	0.140	CDC1	0	0.333	0	0	0.047	10
		CDC2	0	0.667	0	0	0.094	4
BTC	0.281	BTC1	0	0	0.396	0	0.111	2
		BTC2	0	0	0.135	0	0.038	13
		BTC3	0	0	0.081	0	0.023	14
		BTC4	0	0	0.227	0	0.064	7
		BTC5	0	0	0.161	0	0.045	11
TRC	0.239	TRC1	0	0	0	0.327	0.078	6
		TRC2	0	0	0	0.260	0.062	8
		TRC3	0	0	0	0.413	0.099	3

3.2 Integrating AHP with GRA

Grey relational analysis (GRA) is used to determine the relationship or similarity between two series of data in a grey system [10, 11]. The following case demonstrates how AHP can be integrated with GRA to evaluate teaching competence of six college teachers [11-13].

Step 1: Generation of referential series and compared series

Direct evaluation (with a rating from 1 to 7, with a higher value indicating better the ability) is used herein to measure the fourteen sub-criteria, with the five decision makers rating each criterion separately and the five scores then being averaged (see Table 4).

Let X_0 denote the referential series with n entities and let X_i represent the compared series.

$$X_0 = (X_0(1), X_0(2), \cdots, X_0(n)) \tag{6}$$

$$X_i = (X_i(1), X_i(2), \cdots, X_i(n)), i = 1,2,\cdots,m \tag{7}$$

In this study, the referential series is the optimal values for each criterion. Pick out the largest value of each criterion from the six compared series. Thus, we get $X_0 = (6.200, 5.800, \cdots, 5.800)$.

Table 4 Original values in referential series and compared series

Sub-criteria	Referential series (X_0)	Teacher A (X_1)	Teacher B (X_2)	Teacher C (X_3)	Teacher D (X_4)	Teacher E (X_5)	Teacher F (X_6)
PAC1	6.200	6.200	5.800	5.600	5.600	5.200	6.000
PAC2	5.800	5.400	4.600	3.800	5.800	5.200	4.000
PAC3	5.400	4.800	4.000	4.400	5.000	5.400	4.800
PAC4	5.200	5.000	4.400	4.600	5.200	4.000	5.200
CDC1	5.400	4.200	4.800	3.800	4.600	3.800	5.400
CDC2	5.000	4.200	3.800	5.000	4.000	4.000	4.800
BTC1	5.600	4.800	5.200	4.600	4.200	5.000	5.600
BTC2	6.600	5.400	6.400	6.600	4.400	5.200	6.400
BTC3	6.600	6.600	6.200	6.000	6.600	6.400	6.200
BTC4	5.800	4.800	5.200	5.200	5.800	4.800	5.600
BTC5	6.000	5.000	5.400	5.800	6.000	5.200	5.800
TRC1	5.600	5.200	4.600	4.200	5.600	5.400	5.200
TRC2	6.000	5.400	6.000	5.400	5.200	4.800	5.600
TRC3	5.800	5.200	5.600	5.600	4.600	5.000	5.800

Step 2: Normalization of the data

Before calculating grey relational grade, we must perform data pre-processing. The series data can be treated with the following situations to avoid distorting the normalized data. Since the expectancy is the larger the better, it can be expressed by formula (8). Table 5 shows the normalized data.

$$X_i^*(j) = \frac{X_i(j) - \min\limits_k X_i(j)}{\max\limits_k X_i(j) - \min\limits_k X_i(j)} \tag{8}$$

Table 5 Normative mode of the values

Sub-criteria	Referential series (X_0^*)	Teacher A (X_1^*)	Teacher B (X_2^*)	Teacher C (X_3^*)	Teacher D (X_4^*)	Teacher E (X_5^*)	Teacher F (X_6^*)
PAC1	1.000	1.000	0.600	0.400	0.400	0.000	0.800
PAC2	1.000	0.800	0.400	0.000	1.000	0.700	0.100
PAC3	1.000	0.571	0.000	0.286	0.714	1.000	0.571
PAC4	1.000	0.833	0.333	0.500	1.000	0.000	1.000
CDC1	1.000	0.250	0.625	0.000	0.500	0.000	1.000
CDC2	1.000	0.333	0.000	1.000	0.167	0.167	0.833
BTC1	1.000	0.429	0.714	0.286	0.000	0.571	1.000
BTC2	1.000	0.455	0.909	1.000	0.000	0.364	0.909
BTC3	1.000	1.000	0.333	0.000	1.000	0.667	0.333
BTC4	1.000	0.000	0.400	0.400	1.000	0.000	0.800
BTC5	1.000	0.000	0.400	0.800	1.000	0.200	0.800
TRC1	1.000	0.714	0.286	0.000	1.000	0.857	0.714
TRC2	1.000	0.500	1.000	0.500	0.333	0.000	0.667
TRC3	1.000	0.500	0.833	0.833	0.000	0.333	1.000

Step 3: Calculating grey relational coefficient

The grey relational coefficient for series x_0 to x_i is calculated as:

$$\gamma_i(j) = \frac{\Delta\min + \rho\Delta\max}{\Delta_i(j) + \rho\Delta\max} \tag{9}$$

Where $\Delta_i(j) = |X_0(j) - X_i(j)|$, $\Delta\max = \max\limits_i \max\limits_j \Delta_i(j)$, $\Delta\min = \min\limits_i \min\limits_j \Delta_i(j)$ and ρ is the distinguished coefficient, $\rho \in [0,1]$ and typically $\rho = 0.50$ .The grey relational coefficients are shown in table 6.

Table 6 Grey relational coefficients

Sub-criteria	Teacher A (γ_1)	Teacher B (γ_2)	Teacher C (γ_3)	Teacher D (γ_4)	Teacher E (γ_5)	Teacher F (γ_6)
PAC1	1.000	0.556	0.455	0.455	0.333	0.714
PAC2	0.714	0.455	0.333	1.000	0.625	0.357
PAC3	0.538	0.333	0.412	0.636	1.000	0.538
PAC4	0.750	0.429	0.500	1.000	0.333	1.000
CDC1	0.400	0.571	0.333	0.500	0.333	1.000
CDC2	0.429	0.333	1.000	0.375	0.375	0.750
BTC1	0.467	0.636	0.412	0.333	0.538	1.000
BTC2	0.478	0.846	1.000	0.333	0.440	0.846
BTC3	1.000	0.429	0.333	1.000	0.600	0.429
BTC4	0.333	0.455	0.455	1.000	0.333	0.714
BTC5	0.333	0.455	0.714	1.000	0.385	0.714
TRC1	0.636	0.412	0.333	1.000	0.778	0.636
TRC2	0.500	1.000	0.500	0.429	0.333	0.600
TRC3	0.500	0.750	0.750	0.333	0.429	1.000

Step 4: Calculate the grey relational grade

If the weight (w_j) of each criterion is determined, the grey relational grade can be computed using the following formula:

$$\Gamma_i = \sum_{j=1}^{n} w_i(j) \times \gamma_i(j) \tag{10}$$

Select the optimal teacher based on grey relational grades in Table 7. Therefore, teacher F is the best one in teaching competence.

Table 7 Grey relational trade and rank

Candidates	Teacher A	Teacher B	Teacher C	Teacher D	Teacher E	Teacher F
Γ_i	0.562	0.533	0.537	0.614	0.534	0.744
Rank	3	6	4	2	5	1

4. Conclusions and discussions

The evaluation of teaching competence in colleges and universities is a difficult multi-criteria decision making problem. Hence, this study has designed an integrated approach for evaluating teaching competence. The proposed approach comprises two parts. The first part adopts expert's advice combined with the criteria used in previous studies to identify suitable criteria and sub-criteria for evaluating teaching competence, and applies AHP to determine the relative weights of these criteria. According to the ranking of the weights, professional attitude competence is the most important criteria in evaluating teaching competence followed by basic teaching competence, teaching reflection competence and curriculum development competence. The four sub-criteria emphasized most include caring for students, guiding self-regulated learning and discussion, instantly access to feedback information for queries, and original and updated teaching contents. The second part then applies GRA to rank the alternative teachers, and finally selects the optimum teacher in teaching competence. The results reveal that the candidate teachers are ranked as follows: teacher F, teacher D, teacher A, teacher C, teacher E, teacher B. Consequently, teacher F was selected as the ideal teacher in teaching competence. The human resources department in colleges and universities can use this integrated approach in their decision and policy making processes. Moreover, such an integrated approach can be carried out in other similar multi-criteria evaluating problems such as academic competence evaluation.

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