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Application of Fuzzy Synthetic Evaluation Model to the Assessment of Competency of Chinese Teachers

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Evaluation indicators of competency of Chinese teachers are determined by survey and looking up the references. The weights of each indicator are determined by analytic hierarchy process (AHP). The fuzzy synthetic evaluation model is established for competency assessment among Chinese teachers.

1. Introduction

As more attention is given to foreign language teaching in China, the teaching of Chinese language is weakened. However, teaching of Chinese as the mother language is the basis of education, and the competency of Chinese teachers affects the development of China's education on the whole. Chinese teachers should not only possess profound theoretical knowledge of the Chinese language, but also pay attention to the skills in oral communication and innovation of teaching method. In a word, Chinese teachers should undertake more social responsibilities and perform social roles more effectively.

2. Competency indicators and determination of weights of indicators

The indicators of competency of Chinese teachers and their weights differ greatly. According to the features of Chinese language teaching, we propose the competency indicators as follows (Table 1).

Table 1: System of competency indicators of Chinese teachers

Primary indicator	Secondary indicator
Theoretical knowledge	1. Education theory; 2. Specialized knowledge of Chinese language; 3. Frontier knowledge of Chinese language;
Teaching skills	4. Teaching competence; 5. Communication skills; 6. Learning ability; 7. Innovation ability; 8. Oral skills
Teaching attitude	9. Enthusiasm in teaching; 10. Strictness in academic issues; 11. Integrity; 12. Respect for others
Personality and motives	13. Confidence; 14. Sense of accomplishment; 15. Sense of social responsibility; 16. Commitment

There are several methods to calculate the weights of competency indicators. Here we apply AHP to the calculation, which is divided into four steps.
(1) Determining the hierarchy of evaluation indicators of competency of Chinese teachers (Figure. 1) Determining the hierarchy of evaluation indicators of competency of Chinese teachers (Figure. 1)

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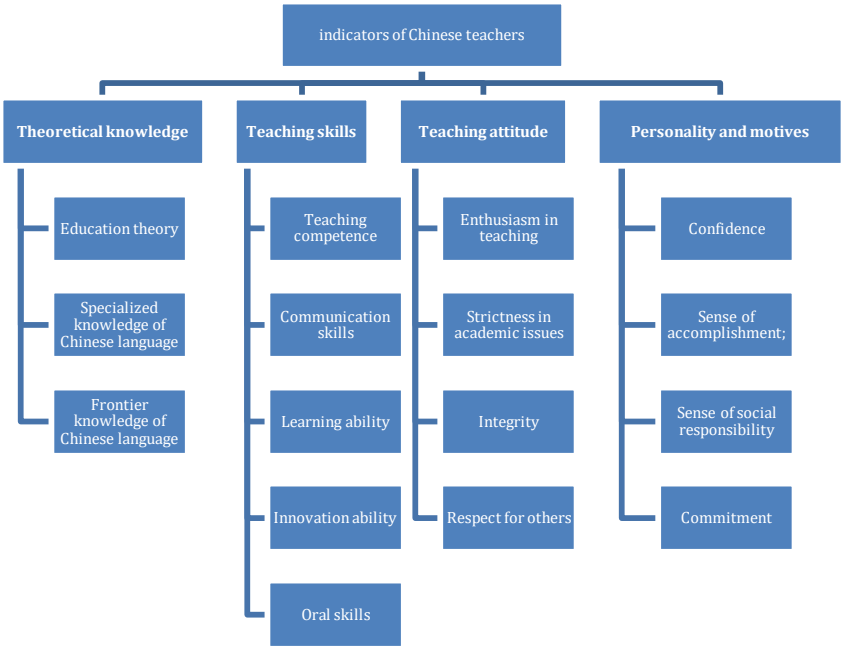

Figure1: Hierarchy of evaluation indicators of competency of Chinese teachers

(2) Establishing pairwise comparison matrix of evaluation indicators of each layer

Suppose there are n indicators on one layer and pairwise comparison is carried out for n indicators. The pairwise comparison matrix is constructed based on the importance of the indicators relative to that of indicators in the upper layer. The matrix is denoted as $A=(a_{ij})_{n\times n}$, where a_{ij} indicates the importance of indicator i and indicator j relative to those in the upper layer. The importance is measured on a scale of 1-9 (Table 2). Here $a_{ij}>0$ and $a_{ij}=\frac{1}{a_{ji}}$, A is positive reciprocal matrix.

Table 2: Scale of 1-9

Value of a_{ij}	Importance of indicator i relative to that of indicator j
1	A_i and A_j have equal influence
3	A_i has slightly stronger influence than A_j
5	A_i has stronger influence than A_j
7	A_i has much stronger influence than A_j
9	A_i has absolutely stronger influence than A_j
2,4,6,8	The influence ratio of A_i to A_j lies between that of two adjacent layers
$\frac{1}{2},\cdots,\frac{1}{9}$	The influence ratio of A_i to A_j is the reciprocal of a_{ij}

(3) Determining the relative weight vector of each competency indicator

For the sake of convenience and practicality, the weights are obtained by geometric averaging in three steps:

a. The product B_i of all elements in each row of pairwise comparison matrix A is calculated, i.e., $B_i = \prod_{j=1}^{n} a_{ij}$, $i = 1, 2, \cdots, n$. Thus vector $B = (B_1, B_2, \cdots, B_n)^T$;

b. The square root is calculated for each component of vector $B = (B_1, B_2, \cdots, B_n)^T$, i.e., $C_i = \sqrt[n]{B_i}$. Thus vector $C = (C_1, C_2, \cdots, C_n)^T$;

c. Vector $C = (C_1, C_2, \cdots, C_n)^T$ is normalized, i.e., $W_i = \frac{C_i}{\sum_{i=1}^{n} C_i}$. Thus the weight of vector is $W = (W_1, W_2, \cdots, W_n)^T$, $i = 1, 2, \cdots, n$.

(4) Consistency test

The weights determined above are considerably affected by subjective factors. To confirm the validity, consistency test is carried out in three steps.

a. Consistency index is calculated as $CI = \frac{\lambda_{\max} - n}{n-1}$, where $\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n} \frac{\sum_{j=1}^{n} a_{ij} W_j}{W_i}$;

b. Random index RI is found by looking up the random consistency index table according to the value of n. Usually RI is given empirically. See Table 3.

c. Consistency ratio is calculated as $CR = \frac{CI}{RI}$. The pairwise comparison matrix is considered as passing the consistency index if $CR < 0.10$.

Table 3: Random index

n	1	2	3	4	5	6	7	8
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41

The weights of each competency indicator are calculated as follows.

a. Weights of each competency indicators

The pairwise comparison matrix is $A = \begin{bmatrix} 1 & 1/2 & 1 & 2 \\ 2 & 1 & 2 & 3 \\ 1 & 1/2 & 1 & 2 \\ 1/2 & 1/3 & 1/2 & 1 \end{bmatrix}$, vector $B = (1, 12, 1, \frac{1}{12})$, vector $C_1 = (1, 1.861, 1, 0.537)$, and weight vector $W = (0.227, 0.423, 0.227, 0.122)^T$.

It is derived that $\lambda_{\max} = \frac{1}{4}(4.005 + 4.015 + 4.005 + 4.016) = 4.010$ and $CI = \frac{4.010 - 4}{4-1} = 0.003356$. With $n = 4$, $RI = 0.90$ by looking up the table. Thus the consistency test is passed.

b. Weights of indicators of theoretical knowledge (here only the pairwise comparison matrix and the weights are given, but the process of calculation and consistency test is omitted)

$A = \begin{bmatrix} 1 & 1/5 & 1/3 \\ 5 & 1 & 3 \\ 3 & 1/3 & 1 \end{bmatrix}$, $W = (0.11, 0.63, 0.26)^T$;

c. Weights of indicators of teaching skills

$$A=\begin{bmatrix} 1 & 2 & 1 & 1 & 1/5 \\ 1/2 & 1 & 1/2 & 1/3 & 1/7 \\ 1 & 2 & 1 & 1/2 & 1/5 \\ 1 & 3 & 2 & 1 & 1/3 \\ 5 & 7 & 5 & 3 & 1 \end{bmatrix},\ W=(0.125,0.062,0.110,0.174,0.529)^T;$$

d. Weights of indicators of teaching attitude

$$A=\begin{bmatrix} 1 & 1/3 & 3 & 5 \\ 3 & 1 & 5 & 7 \\ 1/3 & 1/5 & 1 & 3 \\ 1/5 & 1/7 & 1/3 & 1 \end{bmatrix},\ W=(0.263,0.564,0.118,0.055)^T;$$

e. Weights of indicators of personality and motives

$$A=\begin{bmatrix} 1 & 1/4 & 1/7 & 1/3 \\ 4 & 1 & 1/3 & 2 \\ 7 & 3 & 1 & 5 \\ 3 & 1/2 & 1/5 & 1 \end{bmatrix},\ W=(0.06,0.23,0.577,0.133)^T\ .$$

From the above process the weights of indicators of each layer are calculated, as shown in Table 4.

Table 4: Weights of competency evaluation indicators

Primary indicator	Weight of primary indicator	Secondary indicator	Weight of secondary indicator
Theoretical knowledge	0.227	Education theory	0.11
		Specialized knowledge of Chinese language	0.63
		Frontier knowledge of Chinese language	0.26
Teaching skills	0.423	Teaching competence	0.125
		Communication skills	0.062
		Learning ability	0.110
		Innovation ability	0.174
		Oral skills	0.529
Teaching attitude	0.227	Enthusiasm in teaching	0.263
		Strictness in academic issues	0.564
		Integrity	0.118
		Respect for others	0.055
Personality and motives	0.122	Confidence	0.06
		Sense of accomplishment	0.23
		Sense of social responsibility	0.577
		Commitment	0.133

3. Suggestions

Fuzzy synthetic evaluation model is applied to the assessment of competency of Chinese teachers. For all secondary indicators a 5-category evaluation set is established. The weights of indicators and the fuzzy evaluation matrix are obtained by expert evaluation. The evaluation vector of competency of the Chinese teachers is solved, and the category to which the peak of the evaluation vector belongs indicates the level of

competency of the Chinese teacher (five-level evaluation system). For each secondary indicator the five-level evaluation set is determined, as shown in Table 5.

Table 5: Evaluation set of competency indicators

Secondary indicator	Level 1	Level 2	Level 3	Level 4	Level 5
Education theory	Very good	Good	Moderate	Poor	Very poor
Specialized knowledge of Chinese language	Very good	Good	Moderate	Poor	Very poor
Frontier knowledge of Chinese language	Very good	Good	Moderate	Poor	Very poor
Teaching competence	Very good	Good	Moderate	Poor	Very poor
Communication skills	Very good	Good	Moderate	Poor	Very poor
Learning ability	Very good	Good	Moderate	Poor	Very poor
Innovation ability	Very good	Good	Moderate	Poor	Very poor
Oral skills	Very good	Good	Moderate	Poor	Very poor
Enthusiasm in teaching	Very good	Good	Moderate	Poor	Very poor
Strictness in academic issues	Very good	Good	Moderate	Poor	Very poor
Integrity	Very good	Good	Moderate	Poor	Very poor
Respect for others	Very good	Good	Moderate	Poor	Very poor
Confidence	Very good	Good	Moderate	Poor	Very poor
Sense of accomplishment	Very good	Good	Moderate	Poor	Very poor
Sense of social responsibility	Very good	Good	Moderate	Poor	Very poor
Commitment	Very good	Good	Moderate	Poor	Very poor

The expert panel consists of leaders, colleagues, students and other staff outside the school. The competency is evaluated using the evaluation set of secondary competency indicators. On this basis, the fuzzy evaluation matrix is established.

The evaluation result of the i-th secondary indicator is $(r_{i1}, r_{i2}, r_{i3}, r_{i4}, r_{i5})$ $(i = 1, 2, \cdots, m)$. Then the fuzzy evaluation matrix is

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{15} \\ r_{21} & r_{22} & \cdots & r_{25} \\ \vdots & \vdots & & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{m5} \end{bmatrix},$$

where $r_{ij} = \dfrac{n_j}{n}$ $(i = 1, 2, \cdots, m; j = 1, 2, \cdots, 5)$ is the membership of the i-th secondary indicator to the j-th level. Thus the fuzzy evaluation matrices of 4 primary indicators are obtained as R_A, R_B, R_C and R_D, respectively. The comment vector is

$$V_A = W_A R_A = (\mu_{A_1}, \mu_{A_2}, \mu_{A_3}, \mu_{A_4}) \begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} & r_{15} \\ r_{21} & r_{22} & r_{23} & r_{24} & r_{25} \\ r_{31} & r_{32} & r_{33} & r_{34} & r_{35} \\ r_{41} & r_{42} & r_{43} & r_{44} & r_{45} \end{bmatrix} = (\sum_{i=1}^{3} \mu_{A_i} r_{i1}, \sum_{i=1}^{3} \mu_{A_i} r_{i2}, \sum_{i=1}^{3} \mu_{A_i} r_{i3}, \sum_{i=1}^{3} \mu_{A_i} r_{i4}, \sum_{i=1}^{3} \mu_{A_i} r_{i5}),$$

$$V_B = W_B R_B = (\sum_{i=1}^{5} \mu_{A_i} r_{i1}, \sum_{i=1}^{5} \mu_{A_i} r_{i2}, \sum_{i=1}^{5} \mu_{A_i} r_{i3}, \sum_{i=1}^{5} \mu_{A_i} r_{i4}, \sum_{i=1}^{5} \mu_{A_i} r_{i5});$$

$$V_C = W_C R_C = (\sum_{i=1}^{4} \mu_{A_i} r_{i1}, \sum_{i=1}^{4} \mu_{A_i} r_{i2}, \sum_{i=1}^{4} \mu_{A_i} r_{i3}, \sum_{i=1}^{4} \mu_{A_i} r_{i4}, \sum_{i=1}^{4} \mu_{A_i} r_{i5});$$

$$V_D = W_D R_D = (\sum_{i=1}^{4} \mu_{A_i} r_{i1}, \sum_{i=1}^{4} \mu_{A_i} r_{i2}, \sum_{i=1}^{4} \mu_{A_i} r_{i3}, \sum_{i=1}^{4} \mu_{A_i} r_{i4}, \sum_{i=1}^{4} \mu_{A_i} r_{i5}).$$

Let $R_O = (V_A, V_B, V_C, V_D)^T$. Thus the evaluation vector of competency of the Chinese teacher is

$V = WR = (\mu_A, \mu_B, \mu_C, \mu_D)(V_A, V_B, V_C, V_D)^T$.

After normalization, the category to which the peak of the evaluation vector belongs indicates the level of competency of the Chinese teacher.

4. Application and analysis

The fuzzy synthetic evaluation model established in this study can provide fast and reliable assessment of competency of Chinese teachers. Since the weights of the indicators are determined by AHP, the weights can be adjusted for different situations, preferably by questionnaire survey. This model may be criticized for the use of expert evaluation for determining the secondary indicators. We suggest that the weights of the scores given by different members of the expert panel should be also determined by AHP.

5. Summary

To adapt to the needs of the society, Chinese teachers should undertake new social responsibilities and perform new social roles. Chinese teachers should advance with the times and constantly hone their learning ability and innovation ability, combining oral skills with professional knowledge. This is the precondition for the cultivation of talents qualified in every aspect.

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