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Research Article

The Application of Fuzzy-ANP and SD Software in the Assessment of Organic Chemistry Teachers' Bilingual Teaching Competency

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Abstract: The assessment of organic chemistry teachers' bilingual teaching competency plays a crucial role in improving their teaching quality. In this study, 13 indices in five aspects: teaching quality, teaching content, teaching organization, teaching methods, and teaching effects, have been identified as impact indices for assessing the bilingual teaching competency of organic chemistry teachers. Meanwhile, the ANP (Analytic Network Process) model is set up, and the Super Decisions software is used to compute the comprehensive weight of the 13 impact factors. A five-degree fuzzy comment set including very satisfied, satisfied, mediocre, dissatisfied, and very dissatisfied is established. The five-degree evaluation data on the 13 impact indices are collected through questionnaires distributed to students. Index weights and evaluation data are synthesized to obtain the final assessment results of organic chemistry teachers' bilingual teaching competency. The Fuzzy-ANP model has taken the internal relations and external dependency of 13 indices into consideration, which makes the assessment results more authentic and reliable. Therefore, this model is worthy of a more extensive application.

Keywords: Fuzzy-ANP, Super Decision software, organic chemistry, bilingual teaching competency

INTRODUCTION

The high education in China has developed rapidly in recent years. After the significant expansion of college enrollment and school size, the enhancement of education quality has now been identified as the next important goal for the further development of the higher education in China. And the improvement of teaching quality lays the foundation for the enhancement of education quality. To adapt China's higher education to requirements of the cultivation of international talents, the Ministry of Education and the Ministry of Finance of China have joined their efforts to increase the investment and training programs targeted at bilingual education. In Opinions on Strengthening Undergraduate Education and Improving Teaching Quality, a document issued by the Ministry of Education, the setting up of bilingual programs is highlighted. The basic requirement of bilingual education in international practice is as follows: in the process of education, two languages should be employed as instructional media in a systematic manner to help students develop naturally in both their subject knowledge and bilingual competency. Therefore, bilingual education has the double objectives of attaining the knowledge of a specific discipline and the capacity of using a foreign language. Bilingual education imposes a high requirement on teaching staff, curriculum, textbooks and students. Among these factors, teachers play a leading role; teacher assessment will help promote teachers' enthusiasm and initiative, and the assessment of bilingual teaching competency of teachers has become a research subject of practical significance. Organic chemistry is an important basic course for chemistry, medicine, environmental science and food science, and has found a wide range of applications. Hence the course is suitable for bilingual teaching.

There are many methods available for the assessment of teaching competency, and Fuzzy-AHP (Analytic Hierarchy Process) (Ozan and Canbolat, 2008; Guozhong *et al*., 2012), as one of them, is widely used. However, AHP method could only be used under the following conditions: hierarchical relation exists between different levels, and no interdependence exists between levels or elements. In reality, mutual influence and restriction do exist among impact factors of the assessment of teaching competency, which will lower the accuracy of the assessment. In actual process of decision-making, the elements of the system do not form a hierarchical structure; instead they form a network structure, in which each node represents an element or a set of elements, and each element in the system may influence and control other elements or be influenced or controlled by others. Consequently, ANP method is more suitable for decision making of this particular structure (Marta *et al*., 2011; Ismael and Akbar, 2012). In this research, ANP and fuzzy assessment set have been synthesized to measure organic chemistry teachers' bilingual teaching competency.

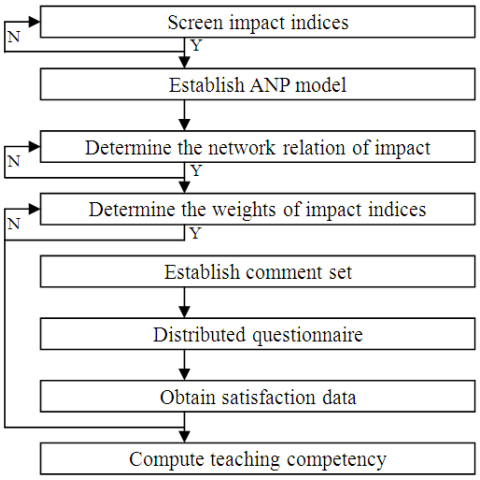


Fig. 1: Assessment process

METHODS

The main steps of assessment are as follows (İhsan and Metin, 2010) (Fig. 1 and Step1-5):

Step 1: establish a set of assessment factors.
Let the set of assessment factors be U.

$$U = \{u_1, u_2, ..., u_n\}$$

Step 2: establish a comment set.

Let the comment set be V, and each degree of the evaluation corresponds to a fuzzy subset.

$$V = \{v_1, v_2, ..., v_m\}$$

The corresponding intermediate value $Med.v$

$$Med.v = \{Med.v_1, \quad Med.v_2, \quad ..., \quad Med.v_m\}.$$

Step 3: establish a fuzzy relational matrix.

Quantify each factor u according to the comment set, i.e., use a single factor to determine the fuzzy subordination degree between the assessed object and each evaluation degree, and then get the fuzzy relational matrix R.

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix}_{n \times m}$$

Step 4: Establish the ANP model and determine the weight of the assessment factors set.

Build the ANP model which contains the control layer and network layer: the control layer is composed of several criteria, and the network layer is composed of clusters and element nodes. Comparison matrix of element nodes compares the importance of nodes among the same clusters or nodes among different clusters, and is also known as local dominance degree. Comparison matrix of the clusters is called the weight matrix; it compares the importance of different clusters with respect to the overall objectives, and is also referred to as global dominance degree. The local dominance degrees of all nodes in a cluster relative to the parent nodes in another cluster (including itself) constitute the matrix assembly. Calculate the comprehensive weight W of each impact factor according to the matrix assembly.

$$W = \{w_1, w_2, ..., w_n\}$$

Step 5: fuzzy comprehensive assessment.

$$B = (b_1, b_2, ..., b_m) = W \circ R = (w_1, w_2, ..., w_n) \circ \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix}$$

$$S = B.Med.v_t$$

APPLICATION OF THE ANP MODEL

Set up assessment factor set and comment set: Based on expert interviews and the principle of operability, these research measures five aspects, namely, teaching quality, teaching content, teaching organization, teaching methods, and teaching effects. 13 indices are ultimately selected to compose the set of assessment factors (Table 1). The comment set is divided into five degrees including very satisfied, satisfied, mediocre, dissatisfied, and very dissatisfied, V_t={80<v_1≤100, 60<v_2≤80, 40<v_3≤60, 20<v_4≤40, 0<v_5≤20}, with corresponding intermediate value Med .v {90, 70, 50, 30, 10}.

Establish the ANP model: Establish the ANP model (Fig. 2, 3) and calculate the weight of each assessment factor by Super Decisions software (Ediz and Basar, 2012). These weights reflect quantitatively the degree of mutual influence between impact factors in the analysis model. The specific steps are as follows: use design-cluster-new order to set up clusters, use design-node-new order to set up element nodes, and use do connexions order to set up the internal connections (internal dependency) within the same cluster as well as connections (external dependency) among different clusters. Use assess/compare-pairwise comparison order to compare the relations between clusters and element nodes on a 1-9 scale, and generate comparison matrix. Comparison should be done in questionnaire mode. Use computations-unweighted super matrix order to calculate the unweighted super matrix of the ANP model, in accordance with the comparison matrix;

Table 1: Assessment index system

Target layer	Criteria layer	Sub-criteria layer
Bilingual teaching competency (A)	Teaching quality(B_1)	Proficiency of bilingual expression(B_{11})
		The knowledge of a specific discipline(B_{12})
		Teaching attitude(B_{13})
	Teaching content(B_2)	The targetedness of bilingual textbooks(B_{21})
		The reasonability of the proportion of bilingual contents(B_{22})
		The reasonability of the course contents(B_{23})
	Teaching organization(B_3)	The reasonability of bilingual contents organization(B_{31})
		The reasonability of time allocation(B_{32})
	Teaching methods(B_4)	Bilingual ability to communicate(B_{41})
		Teaching environment creation(B_{42})
		Flexibility of methods(B_{43})
	Teaching effects(B_5)	Students' mastery of subject knowledge(B_{51})
		Students' improvement in their foreign language skills(B_{52})

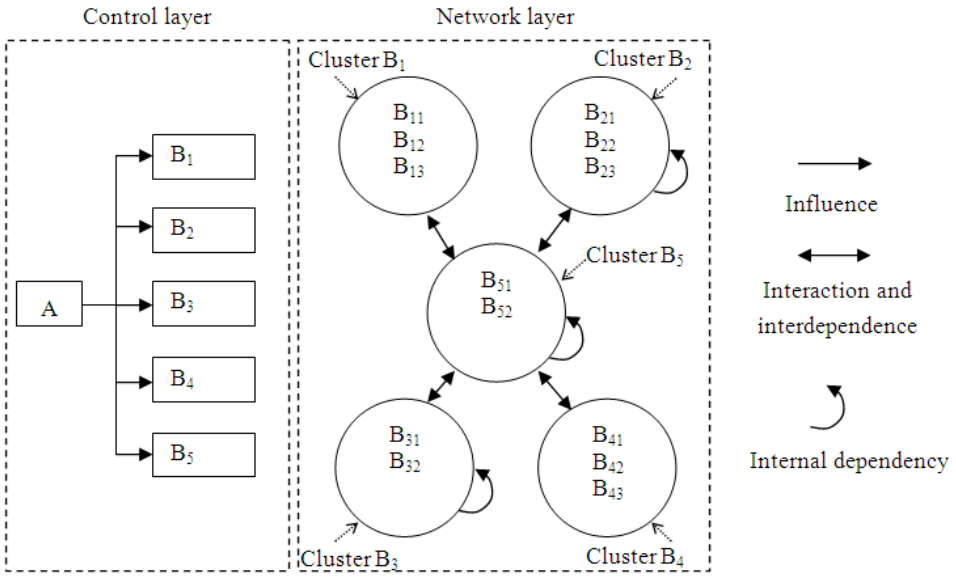


Fig. 2: Assessment ANP model of organic chemistry teachers' bilingual teaching competency

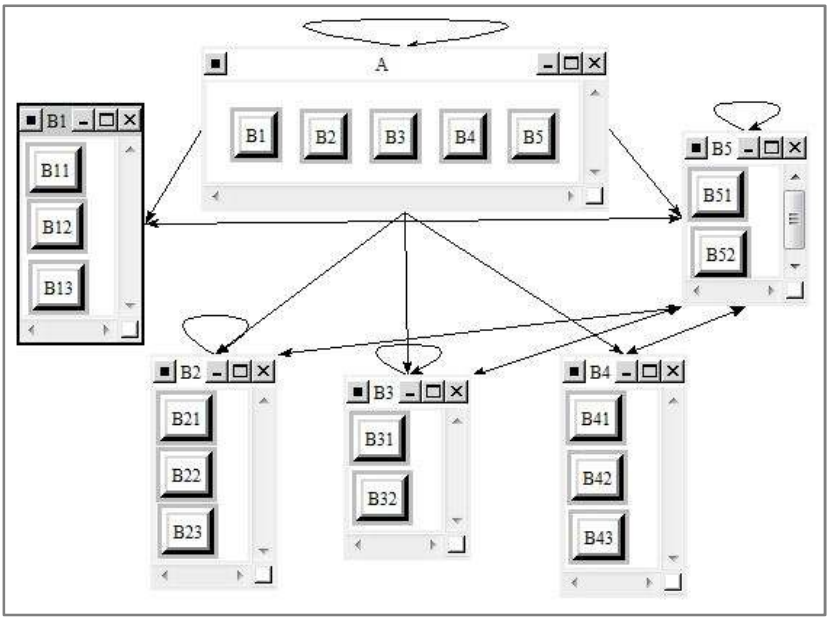
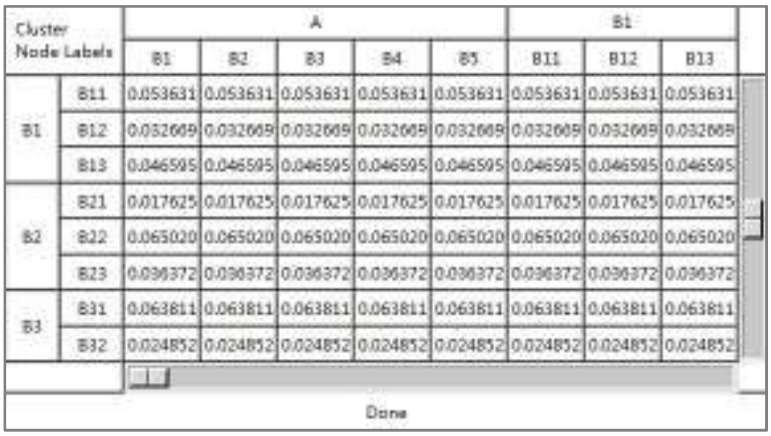


Fig. 3: Assessment ANP model in Super Decision software



Cluster Node Labels		A					B1		
		B1	B2	B3	B4	B5	B11	B12	B13
B1	B11	0.053631	0.053631	0.053631	0.053631	0.053631	0.053631	0.053631	0.053631
	B12	0.032609	0.032609	0.032609	0.032609	0.032609	0.032609	0.032609	0.032609
	B13	0.046595	0.046595	0.046595	0.046595	0.046595	0.046595	0.046595	0.046595
B2	B21	0.017625	0.017625	0.017625	0.017625	0.017625	0.017625	0.017625	0.017625
	B22	0.065020	0.065020	0.065020	0.065020	0.065020	0.065020	0.065020	0.065020
	B23	0.036372	0.036372	0.036372	0.036372	0.036372	0.036372	0.036372	0.036372
B3	B31	0.063811	0.063811	0.063811	0.063811	0.063811	0.063811	0.063811	0.063811
	B32	0.024852	0.024852	0.024852	0.024852	0.024852	0.024852	0.024852	0.024852

Done

Fig. 4: Limit super matrix in Super Decision software

this super matrix represents the degree of local dominance of the corresponding element nodes, and the sum of elements in columns in each matrix assembly is 1. Use computations-weighted super matrix order to calculate the weighted super matrix, which represents the degree of global dominance of the corresponding element nodes, and the sum of elements in columns is 1. Use computations-limit matrix to calculate the limit super matrix (Fig. 4), which is derived from doing power operation on the weighted super matrix, and its weighted value tends towards stability.

RESULTS AND ANALYSIS

Weights of indices (Table 2):

Survey results of students' satisfaction: In this study, 112 students are as respondents. The results of questionnaire survey are shown in Table 3.

Comprehensive assessment results: Follow Step 5 to calculate the assessment results of organic chemistry teachers' bilingual teaching competency. The process is as follows:

$$B = W \circ R = [0.0536 \quad 0.0327 \quad 0.0466 \quad 0.0176 \quad 0.0650 \quad 0.0364 \quad 0.0638 \quad 0.0249 \quad 0.0350 \quad 0.0211 \quad 0.0277 \quad 0.2333 \quad 0.3423]$$

$$\circ \begin{bmatrix} 0.5893 & 0.2143 & 0.1250 & 0.0446 & 0.0268. \\ 0.6696 & 0.0714 & 0.1696 & 0.0625 & 0.0268 \\ 0.7321 & 0.0893 & 0.1161 & 0.0446 & 0.0179 \\ 0.8125 & 0.0893 & 0.0714 & 0.0268 & 0.0000 \\ 0.8214 & 0.0625 & 0.0268 & 0.0446 & 0.0446 \\ 0.7946 & 0.1161 & 0.0714 & 0.0179 & 0.0000 \\ 0.6696 & 0.1964 & 0.0893 & 0.0446 & 0.0000 \\ 0.8036 & 0.1250 & 0.0179 & 0.0179 & 0.0357 \\ 0.7946 & 0.1339 & 0.0268 & 0.0089 & 0.0357 \\ 0.8214 & 0.1429 & 0.0089 & 0.0268 & 0.0000 \\ 0.6071 & 0.2500 & 0.0625 & 0.0714 & 0.0089 \\ 0.7768 & 0.1786 & 0.0268 & 0.0179 & 0.0000 \\ 0.8036 & 0.0804 & 0.0714 & 0.0179 & 0.0268 \end{bmatrix} = [0.7652 \quad 0.1273 \quad 0.0629 \quad 0.0270 \quad 0.0176]$$

$$S = B.Med.v = 0.7652 \times 90 + 0.1273 \times 70 + 0.0629 \times 50 + 0.0270 \times 30 + 0.0176 \times 10 = 81.91$$

The comprehensive assessment of organic chemistry teachers' bilingual teaching competency is "good".

Table 2: Weights of indices

Index	Weight
B_{11}	0.0536
B_{12}	0.0327
B_{13}	0.0466
B_{21}	0.0176
B_{22}	0.0650
B_{23}	0.0364
B_{31}	0.0638
B_{32}	0.0249
B_{41}	0.0350
B_{42}	0.0211
B_{43}	0.0277
B_{51}	0.2333
B_{52}	0.3423

Table 3: Students' satisfaction of indices (Percentage)

Index	v_1	v_2	v_3	v_4	v_5
B_{11}	58.93	21.43	12.50	4.46	2.68
B_{12}	66.96	7.14	16.96	6.25	2.68
B_{13}	73.21	8.93	11.61	4.46	1.79
B_{21}	81.25	8.93	7.14	2.68	0.00
B_{22}	82.14	6.25	2.68	4.46	4.46
B_{23}	79.46	11.61	7.14	1.79	0.00
B_{31}	66.96	19.64	8.93	4.46	0.00
B_{32}	80.36	12.50	1.79	1.79	3.57
B_{41}	79.46	13.39	2.68	0.89	3.57
B_{42}	82.14	14.29	0.89	2.68	0.00
B_{43}	60.71	25.00	6.25	7.14	0.89
B_{51}	77.68	17.86	2.68	1.79	0.00
B_{52}	80.36	8.04	7.14	1.79	2.68

CONCLUSION

The assessment of organic chemistry teachers' bilingual teaching competency can be conducted in five aspects, namely, teaching quality, content, organization, methods and effects. And 13 indices are singled out to compose the assessment factors set. The fuzzy comment set is divided into five degrees including very satisfied, satisfied, mediocre, dissatisfied, and very dissatisfied.

Set up the Fuzzy-ANP model, which takes into account of the internal and external dependency of assessment factors, making the assessment results more authentic and reliable.

The extensive application of ANP used to be impeded by its complex computation, but Super Decisions software provides a solution. This lays the foundation for the wide-ranging use of the ANP model, and simplifies the assessment process of organic chemistry teachers' bilingual teaching competency. The comprehensive weight of the 13 indices can be obtained by using the SD software. The assessment results, synthesized in a fuzzy manner from the assessment factor weight and assessment data, can provide guidance for improving teaching quality.

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