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Constructing Evaluation Model Based on AHP

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Abstract

First we analyzed the ways of evaluating practice teaching quality and the problems existing. Second based on AHP cleared the steps of constructing evaluating model. Then we analyzed the factors of effecting and restricting the quality and efficiency of the system for practice teaching. Evaluation index were selected abiding by operability、rationality、comprehensive and quantitative. Then according to questionnaire and statistical analysis of the relevant data we obtained the weight values of every factor based on AHP and set up scientific、quantitative evaluation model. Last it passed consistency test and showed that the model was scientific and rational.

Keywords*: AHP, quantitative, evaluation model, consistency test*

1. Introduction

The evaluation of practice teaching quality is an important part of the whole practice teaching system. But it is difficult to carry on evaluating quantitative or qualitative because of the diversity of content and the flexibility of organization form. At present, the evaluation of practice teaching quality is still at exploring and the initial stage, the shortages and defects still exist. For example: evaluation way is single, focus more excessively on the result than the process. The quantitative of evaluation index are lack of scientific basis, often based on experience or simple Arithmetic mean. There may be large deviation between evaluation result and actual situation. Then directly affect the accuracy of qualitative also the accuracy of quantitative. For the above problems, we try to apply AHP to set up scientific and quantitative evaluation model and select index following operability、rationality、comprehensive and quantitative. Then we used AHP to seek the weight values of every factor and the comprehensive weight vectors and test passing consistency test.

2. The Implement of AHP on Practice Teaching Quality Evaluation

1) Brief Introduction of AHP

The advantage of AHP proposed by American T.L. Satty is that qualitative and quantitative are combined which is highly logic、systemic 、simplicity and practicality. It is an effective decision-making method for every level and multi-objective planning and decision-making problem. Its basic principle is regarding the complex problems as a big system, then draw orderly hierarchy of every interrelated factor by analyzing many factors of every system. Then ask experts to analyse and judge every factor of every level objectively, giving relatively important quantitative expression. Then set up mathematic model, calculate the relatively important weight values of all factors in every level and sort, last test whether or not satisfy the consistency.

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2) The Basis and Steps of Setting up the Model

First make the problem systematic and hierarchy, set up a structure model. Decompose related factors from top to down to several levels according to the properties, every factor of the same level subordinates the factors of the above one, or affected the factors of the above one. Generally there are the highest level named target level which denotes the achieving goal of applying AHP, the middle level denotes the intermediate links concerned when applying AHP, often strategy level、 restricted level、 criteria level and so on, the bottom denotes various measures provided to the final target.

Second set up comparative judge matrix. When to compare n factors $x_1, x_2, \cdots, x_n$ of some level how to affect the above target Z, use comparing two factors to quantitative "the importance". Each time choose two positive numbers x_i, x_j, the positive number $b_{ij} = \frac{x_i}{x_j}$ denotes the rate of x_i and x_j related to the above target Z.The matrix $A = (b_{ij})_{m\times n}$ obtained named comparative judge matrix, obviously $b_{ij} > 0, b_{ji} = \frac{1}{b_{ij}}, b_{ii} = 1.$ The value of b_{ij} referred to the way proposed by Satty, he quoted number 1 to 9 and their reciprocals as scaling, the meaning seeing Table 1.

Table 1. Scaling Table

scaling	meaning	scaling	meaning
1	Denotes two factors compared, have the same importance	7	Denotes two factors compared, The former is strongly important than the latter
3	Denotes two factors compared, The former is a little important than the latter	9	Denotes two factors compared, The former is extremely important than the latter
5	Denotes two factors compared, The former is apparently important than the latter	2,4,6,8	The between values of the above judgement
reciprocals	If the rate of factor x_i and x_j is b_{ij} ,then that of x_j and x_i is $\frac{1}{b_{ij}}$		

Then making single sort and consistency test.Computing the biggest eigenvalue $\lambda_{\max}$ of every comparative judge matrix and the corresponding eigenvector w_i, the eigenvector w_i satisfied consistency will be the sort weight vector of the under level regarded as more important than the upper level. This process named level single sort.

Test every comparative judge matrix, the steps as follow:

(i) computing consistency index CI, $CI = \frac{\lambda_{\max} - n}{n-1}$;

(ii) find average random consistency index RI, see in Table 2;

(iii) computing random consistency rate CR, $CR = \frac{CI}{RI}$.

Table 2. Average Random Consistency Index *RI*

Dimension of comparative matrix	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

When $CR < 0.1$, the comparative judge matrix is regarded as consistent. Then its eigenvectors are regarded as weight vectors. Or it is need to adjust the matrix again until satisfy the consistency.

Last compute comprehensive weight vectors and make comprehensive consistency test, namely level general sort and consistency test. The above vectors are the ones that one group of factors to their upper level some vector. Finally it is need to get sort weight vectors that every plan of the lowest to the general target. Integrating the final sort weigh vectors top-down. The formula that computing every factor of the general sort weight vectors are

$$w_{ij}^{(l)} = \sum_{j=1}^{m} w_{ij}^{(l-1)} p_{ij}^{(l)} (i = 1,2,\cdots n) \tag{1}$$

The comprehensive consistent rate is

$$CR^{(l)} = \frac{\sum_{j=1}^{n} CI_j^{(l)} w_{ij}^{(l-1)}}{\sum_{j=1}^{n} RI_j^{(l)} w_{ij}^{(l-1)}} \tag{2}$$

When $CR < 0.1$, the final level sort is consistent, or adjust comparative judge matrix again.

3. Analysis of Effecting and Restricting the Factors of Practice Teaching Quality and Set up Evaluating Model

1) Analysis of Effecting and Restricting Practice Teaching Quality Factors

Agreement: b_j denotes final target index; c_j denotes second evaluation index; d_j denotes third evaluation index; e_j denotes fourth evaluation index.

Analyzing the factors that restrict practice teaching quality and efficiency, there are three basic factors namely final target index: object factors b_1, management factors b_2 and subject factors b_3. The three are complementary and affect together the improvement of practice teaching quality. The object and the subject factors restrict the potential quality and efficiency of the practice teaching, functioning by the management. The management factors restrict the practical quality and efficiency.

The object factors are the general object conditions that the produce、research、social and practice are conducting. It is divided into condition factors c_1、 environment factors c_2 and other object factors c_3 according to its role in the practice teaching activity. The condition factor is an essential object condition. Without it the potential of practice teaching cannot be explored effectively. According to its activity content it can be divided into producing practice condition d_1、 experiment practice teaching condition d_2、 social practice condition d_3、 research practice condition d_4 and so on. According to the type of practice teaching activity, the environment factor it can divided into social practice teaching environment d_5、 producing practice teaching environment d_6、research practice teaching environment d_7. The management factor contains: management operating mechanism c_4 、 management conditions c_5、 management ideas c_6、 management principles c_7 、 management system c_8 、 management action c_9 、 management guidelines、 target c_{10} and so on.

The subject factors are the all subjects that accomplish practicing teaching activity. It is

divided into practice factor c_{11} and teaching factor c_{12}. Here practice factor contains managers、workers d_8、researchers d_9 in the research practice. Teaching factor is the subject of teaching activity containing teachers d_{10}, teaching management service staff d_{11} and students d_{12}. The teacher factor is the leading of teaching factors. From the theory, practice teaching requirements the quality of teachers are more highly than the classroom theory. Teachers play a more important role in the teaching practice than in the classroom. Teacher factors contain the scale of the teachers team e_1、qualification and titles e_2、the numbers and ranks of researches e_3. Teaching management services staff are the concrete bearers of practice teaching management work. Their quality determines the level of practice teaching management service. Management services staff quality contains ability and level e_4、service attitude e_5、manage mind and idea e_6. The students play double roles in the teaching practice. The students are both the acceptor in the practice teaching and the subject in the practice activity, also passive factor and active factor. The students factors contain strong sense of collaboration e_7、clear studying motive and active correct attitude e_8、strong practice ability e_9、proper practice ways e_{10}.

2) Set up Evaluation Model

According to the above analysis of factors that restrict practice teaching quality, set up comprehensive evaluating model.

Based on AHP，using questionnaire and expert advisory to set up the judge matrix of every index level seeing the following Table 3-13.Here the weight value w_i of every comparative matrix obtained by the formula named root law:

$$w_i = \frac{\sqrt[n]{\prod_{j=1}^{n} a_{ij}}}{\sum_{k=1}^{n} \sqrt[n]{\prod_{j=1}^{n} a_{kj}}} \quad (a_{ij} \text{ is the element of every matrix}) \tag{3}$$

Taking the final target index as an example, the related results computed in detail as follows:

$$CI = \frac{\lambda_{\max} - n}{n-1} = \frac{3.02-3}{3-1} = 0.01,\ RI^{(2)} = 0.58,\ CR^{(2)} = \frac{CI}{RI^{(2)}} = 0.0172 < 0.1$$

$$w_1^{(2)} = \frac{\sqrt[3]{1+1/5+1/3}}{\sqrt[3]{1+1/5+1/3}+\sqrt[3]{5+1+2}+\sqrt[3]{5+3+1}} = 0.22$$

$$w_2^{(2)} = \frac{\sqrt[3]{5+1+2}}{\sqrt[3]{1+1/5+1/3}+\sqrt[3]{5+1+2}+\sqrt[3]{5+3+1}} = 0.38$$

$$w_3^{(2)} = \frac{\sqrt[3]{5+3+1}}{\sqrt[3]{1+1/5+1/3}+\sqrt[3]{5+1+2}+\sqrt[3]{5+3+1}} = 0.40$$

$$w^{(2)} = (0.22, 0.38, 0.40)'$$

Therefore, the judge matrix of the final target index can be obtained, which is summarized in Table 3.

Table 3. Judge Matrix of the Final Target Index

A	b_1	b_2	b_3	$w^{(2)}$	Consistency test
b_1	1	$1/5$	$1/3$	0.22	$\lambda_{\max} = 3.02$
b_2	5	1	2	0.38	$CI^{(2)} = 0.01$， $RI^{(2)} = 0.58$
b_3	5	3	1	0.40	$CR^{(2)} = 0.0172 < 0.1$

Similarly, Table 4 to Table 13 can be obtained in the same way, and the detail computations were omitted.

Table 4. Judge Matrix of Object Factors Index

b_1	c_1	c_2	c_3	$p_{1j}^{(3)}$	Consistency test
c_1	1	2	5	0.38	$\lambda_{\max} = 3.02$
c_2	$1/2$	1	3	0.40	$CI_1^{(2)} = 0.01$， $RI_1^{(2)} = 0.58$
c_3	$1/5$	$1/3$	1	0.22	$CR_1^{(2)} = 0.0172 < 0.1$

Table 5. Judge Matrix of Management Factors Index

b_2	c_4	c_5	c_6	c_7	c_8	c_9	c_{10}	$p_{2j}^{(3)}$	Consistency test
c_4	1	3	2	5	$1/2$	4	2	0.22	$\lambda_{\max} = 7.7$
c_5	$1/3$	1	$1/2$	3	$1/4$	2	1	0.08	$CI_2^{(3)} = 0.1206$
c_6	$1/2$	2	1	4	$1/3$	3	1	0.14	$RI_2^{(3)} = 1.24$
c_7	$1/5$	$1/3$	$1/4$	1	$1/6$	$1/2$	$1/4$	0.04	$CR^{(3)}{}_2 < 0.1$
c_8	2	4	3	6	1	5	3	0.33	
c_9	$1/4$	$1/2$	$1/3$	2	$1/5$	1	$1/3$	0.05	
c_{10}	$1/2$	2	1	4	$1/3$	3	1	0.14	

Table 6. Judge Matrix of Subject Factors Index

b_3	c_{11}	c_{12}	$p_{3j}^{(3)}$	Consistency test
c_{11}	1	$1/2$	0.33	$\lambda_{\max} = 2.02$
c_{12}	2	1	0.67	$CI_3^{(3)} = 0.02$， $RI_3^{(3)} = 0$

Table 7. Judge Matrix of Condition Factors Index

c_1	d_1	d_2	d_3	d_4	$p_{1j}^{(4)}$	Consistency test
d_1	1	$1/5$	$1/3$	$1/2$	0.08	$\lambda_{\max} = 4.19$
d_2	3	1	4	5	0.59	$CI_1^{(4)} = 0.063, RI_1^{(4)} = 0.09$
d_3	3	$1/4$	1	2	0.21	$CR_1^{(4)} = 0.07 < 0.1$
d_4	2	$1/5$	$1/2$	1	0.12	

Table 8. Judge Matrix of Environment Factors Index

c_2	d_5	d_6	d_7	$p_{2j}^{(4)}$	Consistency test
d_5	1	7	5	0.73	$\lambda_{\max} = 3.07$
d_6	$1/7$	1	$1/3$	0.08	$CI_2^{(4)} = 0.035, RI_2^{(4)} = 0.58$
d_7	$1/5$	3	1	0.19	$CR_2^{(4)} = 0.0603 < 0.1$

Table 9. Judge Matrix of Practice Subject Factors Index

c_{11}	d_8	d_9	$p_{3j}^{(4)}$	Consistency test
d_8	1	2	0.67	$\lambda_{\max} = 2.02$
d_9	$1/2$	1	0.33	$CI_3^{(3)} = 0.02$, $RI_3^{(3)} = 0$

Table 10. Judge Matrix of Teaching Subject Factors Index

c_{12}	d_{10}	d_{11}	d_{12}	$p_{4j}^{(4)}$	Consistency test
d_{10}	1	5	7	0.73	$\lambda_{\max} = 3.07$
d_{11}	$1/5$	1	3	0.19	$CI_{12}^{(4)} = 0.035, RI_{12}^{(4)} = 0.58$
d_{12}	$1/7$	$1/3$	1	0.08	$CR_{12}^{(4)} = 0.0603 < 0.1$

Table 11. Judge Matrix of Teacher Factors

d_{10}	e_1	e_2	e_3	$p_{1j}^{(5)}$	Consistency test
e_1	1	$1/7$	$1/3$	0.08	$\lambda_{\max} = 3.07$
e_2	7	1	5	0.73	$CI_{10}^{(5)} = 0.035$, $RI_{10}^{(5)} = 0.58$
e_3	3	$1/5$	1	0.19	$CR_{10}^{(5)} = 0.0603 < 0.1$

Table 12. Judge Matrix of Teaching Management Service Staff

d_{11}	e_4	e_5	e_5	$p_{2j}^{(5)}$	Consistency test
e_4	1	3	$1/5$	0.19	$\lambda_{\max}=3.075$
e_5	$1/3$	1	$1/7$	0.08	$CI_{11}^{(5)}=0.035\ RI_{11}^{(5)}=0.58$
e_5	5	7	1	0.73	$CR_{11}^{(5)}=0.0603<0.1$

Table 13. Judge Matrix of Student Factors Index

d_{12}	e_7	e_8	e_9	e_{10}	$p_{3j}^{(5)}$	Consistency test
e_7	1	$1/5$	$1/3$	$1/2$	0.08	$\lambda_{\max}=4.19$
e_8	5	1	4	5	0.59	$CI_{12}^{(5)}=0.065$， $RI_{12}^{(5)}=0.9$
e_9	3	$1/4$	1	2	0.21	$CR_{12}^{(5)}=0.07<0.1$
e_{10}	2	$1/5$	$1/2$	1	0.12	

$$w^3=\begin{pmatrix}0.11\times0.58,0.11\times0.31,0.11\times0.11,0.58\times0.22,0.58\times0.08,0.58\times0.14,\\0.58\times0.04,0.58\times0.33,0.58\times0.05,0.58\times0.14,0.31\times0.33,0.31\times0.67\end{pmatrix}$$
$$=(0.0638,0.0341,0.0121,0.1276,0.0464,0.0812,0.0232,0.1914,0.0290,0.0812,0.1023,0.0277)$$

$$CI^{(3)}=\left(CI_1^{(3)},CI_2^{(3)},CI_3^{(3)}\right)\left(W^{(2)}\right)=(0.01,0.12,0.02)\begin{pmatrix}0.11\\0.58\\0.31\end{pmatrix}=0.0769$$

$$RI^{(3)}=\left(RI_1^{(3)},RI_2^{(3)},RI_3^{(3)}\right)\left(W^{(2)}\right)=(0.58,0.12,0)\begin{pmatrix}0.11\\0.58\\0.31\end{pmatrix}=0.783$$

$$CR^{(3)}=\frac{CI^{(3)}}{RI^{(3)}}=\frac{0.0769}{0.789}=0.09821<0.1.$$

Similarly，we can get the following quantum:

$$w^{(4)}=\begin{pmatrix}0.0638\times0.08,\ 0.0638\times0.59,\ 0.0638\times0.21,\ 0.0638\times0.12,\ 0.0341\times0.73,\ 0.0341\times0.08,\\0.0341\times0.19,\ 0.0121\times0.67,\ 0.0121\times0.33,\ 0.2077\times0.73,\ 0.2077\times0.19,\ 0.2077\times0.08\end{pmatrix}$$
$$=\begin{pmatrix}0.005104,0.037642,0.013398,0.007656,0.024893,0.02728,0.006479,\\0.0081070.003993,0.151621,0.039463,0.016616\end{pmatrix}$$

And $CI^{(4)}=0.0145284, RI^{(4)}=0.197664$, obviously $CR^{(4)}<0.1.$

$$w^{(5)}=\begin{pmatrix}0.1516\times0.08,\ 0.1516\times0.73,\ 0.1516\times0.19,\ 0.1516\times0.19,\ 0.039463\times0.08\\0.039463\times0.73,\ 0.016616\times0.08,\ 0.016616\times0.59,\ 0.016616\times0.21,\ 0.016616\times0.12\end{pmatrix}$$
$$=\begin{pmatrix}0.0121297,0.110683,0.028808,0.0074977,0.00315704,0.028808,\\0.00132928,0.00980344,0.00348936,0.00199392\end{pmatrix}$$

And $CI^{(5)} = 0.00773476, RI^{(5)} = 0.1257831, CR^{(5)} < 0.1.$

4. Conclusion

In this paper, we first analyzed the existing problems in practice teaching quality system and the researching direction and target. Second based on AHP, we set up hierarchy model: constructing comparative judge matrix, single sort and consistency test, computing comprehensive weight vectors and making comprehensive consistency test, namely total sort and consistency test. Last we analyzed the factors that constraint practice teaching quality and effect. The final target factors contained object factor、subject factor and management factor, here they containing many second level、third level and fourth level index. Then set up comprehensive evaluation index system of practice teaching quality, here the weight vectors of every matrix given by the above formula, and passed the consistent test showing that the matrix constructed are rational and feasible.

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