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Fuzzy Evaluation Study of Outstanding Engineers Training Quality based on Outcome-based Education

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Abstract

To improve outstanding engineers' training quality, using outcome-based education, the evaluation index system of outstanding engineers training quality based on outcome-based education is constructed, the fuzzy evaluation model of training quality based on outcome-based education is constructed with improved analytic hierarchy process and fuzzy comprehensive evaluation, so its efficiency will be higher than ordinary method and the result will be closer to education application. The effectiveness of the proposed method is verified by the evaluation results of mechanical design, manufacture and automation outstanding engineers training quality in North China University of Water Resource and Electric Power, besides it is proved that this method can improve the quality of teaching & learning and improving the training quality of outstanding engineers.

Keywords: outcome-based education, outstanding engineers, training quality, fuzzy evaluation.

1. Introduction

In June 23, 2010, China launched the " outstanding engineers education and training program", its goal is to create a large number of high quality engineering and technical person with innovative capability and meeting the needs of economic and social development for the nation, evaluating outstanding engineers training quality timely and reasonably, ensuring to cultivate excellent outstanding engineers is the core mission of engineering education in colleges and universities [1-3]. At present, the engineering education quality is evaluated by the traditional evaluation ideas based input and qualitative evaluation results, the difficulties in the employment of graduates are caused by many factors such as the lag of educational quality, unmatching with the engineering education graduates comprehensive quality and the social requirements, if the outcome evaluation idea is adopted, which can to solve the above problems effectively, improve the quality of teaching and learning, improve the training quality of outstanding engineers[4-8].So, to improve outstanding engineers' training quality, using outcome-based education, the fuzzy evaluation model of training quality based on outcome-based education is constructed with improved analytic hierarchy process and fuzzy comprehensive evaluation, training quality is evaluated with taking mechanical design, manufacture and automation outstanding engineers in North China University of Water Resource and Electric Power as an example.

2. Analyzing on the Training Quality Evaluation Factors based on Outcome-based Education

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Compared with the traditional evaluation way of higher engineering education and outcome-based evaluation, the results value orientation has basically changed , the former emphasizes students-centered and pays attention to the realization degree of the study result, the latter emphasizes to school and teachers as the center and pays more attention to achievement of teaching goals[6-8]. Because of excellent engineers training quality evaluation involving many complex and factors, under the systematic，scientific and operational principle, the outstanding engineering training quality evaluation index system is constructed based on result orientation with fully consideration the outstanding engineer training goal of practice and innovation, as shown in Fig.1, one level indexes has knowledge outcomes, skill outcomes and non-cognitive outcomes, two level indexes have general knowledge, professional knowledge, mathematical application, critical thinking, information processing, creative design, engineering practice, technology application, moral reason, teamwork and communication.

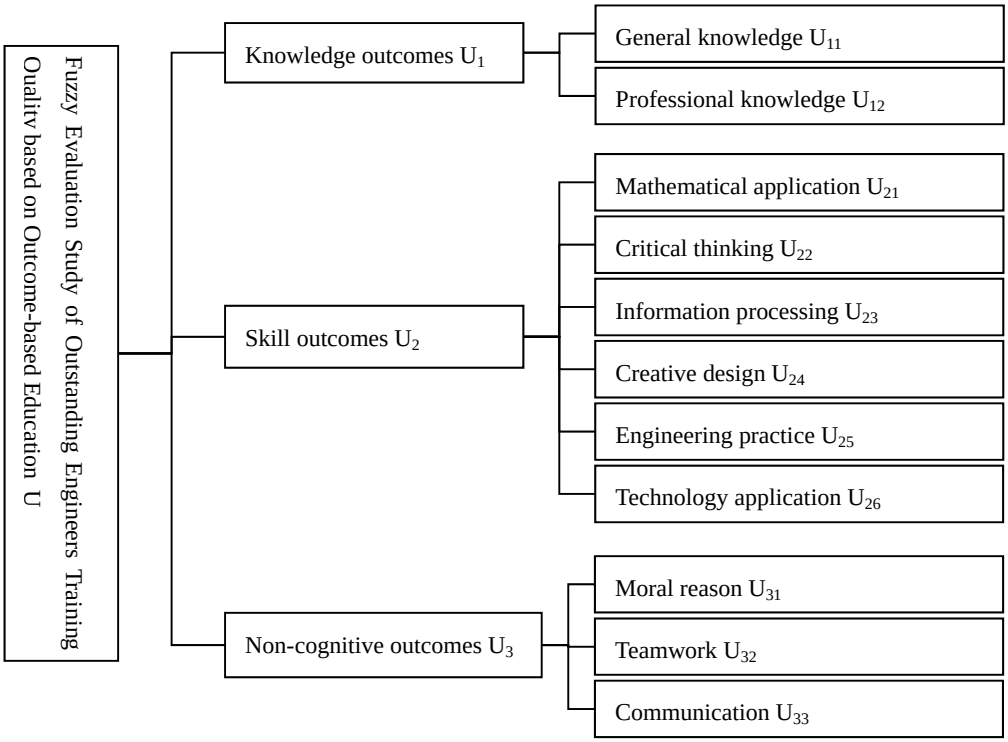

Fig. 1. Outstanding engineering training quality evaluation index system based on outcome-based education

3. Establishing Quality Evaluation Model of Outstanding Engineer Training Based on Outcome-based Education

Analytic hierarchy process is a systematic analysis method combining qualitative analysis with quantitative analysis [10-11]. The traditional analytic hierarchy process needs to carry on the tedious consistency test and complex calculation; the subjectivity of the traditional fuzzy comprehensive appraisal method is strong through the expert directly determine the membership degree matrix [9-11]. The weight of each index is determined by the improved analytic hierarchy process, the evaluation is done though the fuzzy comprehensive evaluation method, it solves the problems of the consistency of judgment matrix and the too subjective membership degree. The main steps are as follows:

3.1 Making Certain Factor Set and Review Set

According to the evaluation index system of Fig.1, the quality evaluation factor set of outstanding engineer training based on outcome-based education $U = \{U_1, U_2, \cdots, U_n\}$, $n = 3$, and the factor set is divided into sub evaluation factor set according to the attribute $U_i = \{U_{i1}, U_{i2}, \cdots, U_{im}\}$, $i = 1,2, \cdots, n$; among them, $i = 1, m = 2; i = 2, m = 6; i = 3, m = 3$.

General comment set is $V = \{V_1, V_2, \cdots, V_c\}, c = 3 - 5$, according to the current training of outstanding engineers, it uses five levels of “very high”, “high”, “general”, “low” and “very low”, the corresponding standard values are 9，7，5，3，1.

3.2 Determining Weights

The improved analytic hierarchy process needs no consistency test through using a new three scale method. In addition, the method can greatly reduce the number of iterations, and improve the convergence rate; the model meets the requirements of calculation accuracy.

（1）Constructing comparison matrix $A = (a_{ij})_{n\times n}$, a_{ij} is the importance level of i element and j element。Using the new 0,1,2 three scaling method, a_{ij} is assigned, and $a_{ii} = 1$。At the same time, the importance sorting index a_i is calculated, and $a_i = \sum_{j=1}^{n} a_{ij}$,then $a_{\max} = \max\{a_i\}$ and $a_{\min} = \min\{a_i\}$ are defined。

（2）Calculating judgment matrix $A' = (a'_{ij})_{n\times n}$, a'_{ij} is calculated according to the follow Eq.（1）。

$$a'_{ij} = \begin{cases} \dfrac{a_i - a_j}{a_{\max} - a_{\min}} \times \left(\dfrac{a_{\max}}{a_{\min}} - 1\right) + 1 & a_i \geq a_j \\ \left[\dfrac{|a_i - a_j|}{a_{\max} - a_{\min}} \times \left(\dfrac{a_{\max}}{a_{\min}} - 1\right) + 1\right]^{-1} & a_i \prec a_j \end{cases} \quad (1)$$

（3） Calculating optimal transfer matrix $O = (o_{ij})_{n\times n}$ and quasi optimal consistent matrix $D = (d_{ij})_{n\times n}$, o_{ij} and d_{ij} is calculated according to the follow Eq.（2）.

$$o_{ij} = \frac{1}{n}\sum_{k=1}^{n}\left(\lg\frac{a'_{ik}}{a'_{jk}}\right), \quad d_{ij} = 10^{o_{ij}} \quad (2)$$

（4）Calculating the feature vector of D, and doing the normalized process to the vector, then the weight vector W of the factors can be gated, $W = [w_1, w_2, \cdots, w_n]^T$, $0 \leq w_i \leq 1, \sum_{i=1}^{n} w_i = 1$。

3.3 Constructing membership degree matrix

The trapezoidal distribution method is used to calculate the membership function, and the membership function of each index is determined, then it can get the membership degree r_{ij} of the factor U_i to the $V_j(j = 1,2,\cdots 5)$, further get the evaluation set $r_i = (r_{i1}, r_{i2}, \cdots r_{i5})$ of the factor U_i, and meet $\sum_{j=1}^{5} r_{ij} = 1$。

Descending semi step type equation of membership degree should look as follow Eq.（3）.

$$r_{ij} = \begin{cases} 1 & x_i \le s_{i,j} \\ \dfrac{s_{i,j+1} - x_i}{s_{i,j+1} - s_{i,j}} & s_{i,j} \le x_i \le s_{i,j+1} \\ 0 & x_i \ge s_{i,j+1} \end{cases} \quad (3)$$

In the Eq.(3): the x_i is the measured value of the i criteria; $s_{i,j}$ is the standard value of the j levels corresponding to the i evaluation indexes.

Ascending semi step type equation of membership degree should look as follow Eq.（4）.

$$r_{ij} = \begin{cases} 0 & x_i \le s_{i,j-1} \\ \dfrac{x_i - s_{i,j-1}}{s_{i,j} - s_{i,j-1}} & s_{i,j-1} \le x_i \le s_{i,j} \\ 1 & x_i \ge s_{i,j} \end{cases} \quad (4)$$

3.4 Evaluating training quality with fuzzy comprehensive model

According to the evaluation index system of figure 1, the improved fuzzy comprehensive evaluation of two levels is carried out. First of all, the second level indicators are evaluated, the membership degree B_i of each first level indicator is calculated by the Eq. (5), and its normalization B_i' is obtained.

$$B_i = W_i \circ R_i \quad (5)$$

In the Eq.(5): B_i is the fuzzy evaluation vector of i first level indicator; W_i is the weight vector of i first level indicator; R_i is the membership degree matrix of i first level indicator; $\circ$ is the $M(\bullet,\oplus)$ operator.

So the fuzzy evaluation matrix $R = \left[B_1', B'_2, \cdots, B'_n\right]^T$ is gated.

Secondly, fuzzy comprehensive evaluation is made on the first level index, and fuzzy comprehensive evaluation vector B is obtained by $B = W \circ R$, in the formula W is the weight vector of the main criterion layer factors on the target layer. the final evaluation rating is determined according to the maximum membership degree.

4. Application Example

According to the relevant data of mechanical design, manufacture and automation outstanding engineers training quality in North China University of Water Resource and Electric Power, the measured values of the second level indicators are gated, it should look as Table 1, by using expert evaluation method, the comparison matrix of the first level and the second level indexes are obtained , it should look

as Table 2, the instance of the quality evaluation model of outstanding engineer training based on outcome-based education in 2 is applied.

Table 1. Measured values of the second level indicators

Indicator	U_{11}	U_{12}	U_{21}	U_{22}	U_{23}	U_{24}	U_{25}	U_{26}	U_{31}	U_{32}	U_{33}
Measured Value	10	8	9	5	6	9	3	8	8	4	2

Table 2. Comparison matrix between indicators

U	U_1	U_2	U_3
U_1	1	0	1
U_2	2	1	2
U_3	1	0	1

U_1	U_{11}	U_{12}
U_{11}	1	1
U_{12}	1	1

U_3	U_{31}	U_{32}	U_{33}
U_{31}	1	2	2
U_{32}	0	1	2
U_{33}	0	0	1

U_2	U_{21}	U_{22}	U_{23}	U_{24}	U_{25}	U_{26}
U_{21}	1	0	0	0	0	0
U_{22}	2	1	0	0	0	0
U_{23}	2	2	1	0	0	0
U_{24}	2	2	2	1	0	2
U_{25}	2	2	2	2	1	2
U_{26}	2	2	2	0	0	1

The weight of each index is calculated according to 3.2, That is:

$$W_U = (0.154 \quad 0.692 \quad 0.154)^T \quad W_{U_1} = (0.5 \quad 0.5)^T$$

$$W_{U_2} = (0.023 \quad 0.038 \quad 0.065 \quad 0.310 \quad 0.344 \quad 0.219)^T \qquad W_{U_3} = (0.637 \quad 0.258 \quad 0.105)^T$$

In accordance with 3.3, the membership value of the second evaluation indicators is calculated and is shown in table 3.

Table 3. Membership value of the second evaluation indicators

r_{ij}	V_1	V_2	V_3	V_4	V_5
U_{11}	0.30	0.25	0.25	0.20	0.00
U_{12}	0.20	0.25	0.30	0.10	0.15
U_{31}	0.35	0.30	0.25	0.05	0.05
U_{32}	0.25	0.20	0.30	0.25	0.00
U_{33}	0.30	0.20	0.25	0.25	0.00

r_{ij}	V_1	V_2	V_3	V_4	V_5
U_{21}	0.00	0.40	0.25	0.35	0.00
U_{22}	0.10	0.25	0.35	0.30	0.00
U_{23}	0.45	0.30	0.25	0.00	0.00
U_{24}	0.30	0.35	0.25	0.10	0.00
U_{25}	0.35	0.55	0.10	0.00	0.00
U_{26}	0.00	0.25	0.25	0.40	0.10

In accordance with 3.4, the fuzzy evaluation vector of the first evaluation indexes and the target fuzzy evaluation vector are obtained.

$$B_1 = (0.75 \quad 0.25 \quad 0 \quad 0 \quad 0) \quad B_2 = (0.442 \quad 0.142 \quad 0.071 \quad 0.345 \quad 0)$$

$$B_3 = (0.313 \quad 0.313 \quad 0.127 \quad 0.178 \quad 0.051) \quad B = (0.470 \quad 0.185 \quad 0.069 \quad 0.266 \quad 0.008)$$

According to the maximum subordination principle, mechanical design, manufacture and automation

outstanding engineers training quality level from North China University of Water Resource and Electric Power the professional is very high, that can accord with the actual circumstance and show that the evaluation method is effective and practical.

5. Conclusions

According to the training objectives and standards of the outstanding engineers, using the outcome-based education concept, the evaluation index system of outstanding engineers training quality based on outcome-based education is constructed, the improved AHP and fuzzy comprehensive evaluation method are applied to the training quality evaluation of the outstanding engineers, the improved analytic hierarchy process does not need to construct the judgment matrix, fuzzy comprehensive evaluation is improved by taking into account the fuzziness of the index and the subjectivity of the membership degree, the evaluation efficiency is improved, so that the evaluation results are more close to the actual training. The example proves that the method is scientific and effective, and it can improve the quality of teaching and learning effectively, and improve the training quality of the outstanding engineers.

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