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STUDY ON GRADUATE SECOND-ROUND EXAMINATION EVALUATION SYSTEM BASED ON AHP FUZZY COMPREHENSIVE EVALUATION

[1]HUILAN LI, [2]LEI ZHOU, [3]CHUNLING SUN, [4]JIANHUI WU,[5]YU SU

[1]Assoc. Prof, Department of Graduate, Hebei United University, Tang Shan 063009, Hebei, China
[2]Lecturer. Prof, Department of Graduate, Hebei United University, Tang Shan 063009, Hebei, China
[3]Prof, Department of Foreign Languages, Hebei United University, Tang Shan 063009, Hebei, China
[4] Lecturer, Hebei Province Key Laboratory of Occupational Health and safety for Coal Industry, Division of Epidemiology and Health Statistics, Hebei United University, Tang Shan 063009, Hebei, China
[5] Lecturer, Hebei Province Key Laboratory of Occupational Health and safety for Coal Industry, Division of Epidemiology and Health Statistics, Hebei United University, Tang Shan 063009, Hebei, China
E-mail: [1]lihuilan1966@163.com

ABSTRACT

In order to evaluate the graduates attending second-round examination objectively, this study established graduate second-round examination evaluate system based on Analytic Hierarchy Process (AHP) and Fuzzy comprehensive evaluation method. Evaluation indexes in the system included knowledge structure, scientific research ability and comprehensive quality of graduates attending second-round examination. At first, AHP was used to determine the weight of each index in the evaluation system and calculated the combination weight of measure indexes. And then according to the amount of index weight and expert's evaluation scores. Fuzzy comprehensive evaluation method was used to evaluate graduates attending second-round examination. Owing to qualitative indexes quantified in the evaluation, evaluation results reflected graduates' real level more objectively and reasonably. Graduate second-round examination evaluation system provided theoretical basis for graduate second-round examination reform in local colleges and universities.

Keywords: *Analytic Hierarchy Process, Fuzzy Comprehensive Evaluation, Graduate, Second-Round Examination, Evaluation System*

1. INTRODUCTION

China's graduate education does not get rid of the shackles of examination-oriented education and the core status of ability education fails to be established in graduate education. The existing enrollment mode can't evaluate the examinee's practical ability, and the established "short-term promotion" employment guidance mode doesn't view improving graduate career choice and adoption ability as its aim and objective, which couldn't meet the individual graduate and social diversified demands. So it is urgent to reform graduate enrollment, employment and entrepreneurship mode [1-6]. Existing researches on graduate enrollment, employment and entrepreneurship are only limited in simple discussions on either enrollment or employment, lacking integrated and systematic understanding, splitting the inner link of ability education between graduate enrollment and employment, disfavoring the integrity of the reform and the consistency of the target, affecting the performance of graduate education reform, lacking the researches on systematic and mutual connection of enrollment and employment mode reform with ability education as its core and basis[6-10]. In addition, statistics and quantitative analysis were insufficient and its theories lacked data support [11-14]. Therefore, the study provided realization route to graduate enrollment , employment and entrepreneurship mode reform by constructing and implementing graduate enrollment ability evaluation system based on Analytic Hierarchy Process (AHP)and Fuzzy comprehensive evaluation method in order to develop and perfect graduate enrollment ability selection mechanism, to improve the performance of graduate employment promotion, and to make up for the shortage of quantitative analysis and to provide data support and theoretical basis for follow-up study.

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2. THE PRINCIPLE OF AHF FUZZY COMPREHENSIVE EVALUATION MODEL

AHP fuzzy comprehensive evaluation model included two parts---- Analytic Hierarchy Process (AHP) and Fuzzy comprehensive evaluation (Fuzzy). In short, AHP was the core part of the model, in which the evaluation object was regarded as a system, and was evaluated by several different questions. Then according to the nature of these questions and the ultimate goal, every question was decomposed into some different composition elements which were divided into different layers according to the subordinate relations between the elements [15-19]. Then the weight of every factor was obtained through certain methods, thus forming a multi-level hierarchical structure system. This process made a complex problem well organized and more hierarchical which was easier to make quantitative analysis. Fuzzy was a common means in comprehensive evaluation, which calculated the membership degree of indexes of every layer based on the weight of every element calculated by AHP. Maximum membership degree principle was used to evaluate the ultimate attributes of every evaluation object. Following AHP analysis, Fuzzy was used to make fuzzy evaluation. Only the combination of the two methods could effectively improve the accuracy and reliability of the evaluation model.

2.1. AHP Was Used To Determine The Weights Of Every Element

AHP was a systematic analysis method using the qualitative analysis and quantitative analysis at the same time. This method could make the complicated question systematic, quantitative and modeling. That is to say, for a complicated question, first of all, it was decomposed into several composition elements, and these elements were further divided into more definite, specific and quantifiable small elements---indexes. Then the weights of every factor were determined according to the importance of the various factors within the same layer. At last a multi-goal and multi-level statistical mode was established after connecting each layer by using weights. The basic steps were as followed.

2.1.1 Establishing a multi-level hierarchical structure to form the target tree diagram

Hierarchical analysis model generally consisted of three layers, namely, top, middle layer and the lowest layer (figure 1). The top was the target layer, namely the general objective in hierarchy analysis. The middle, called constraint layer was one of main factors influencing the total goal; the lowest, called measure layer was the final measure to solve the questions [20-21]. All of these were quantifiable indexes.

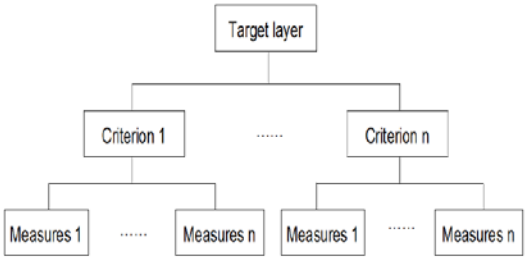

Figure 1: Mode structure of Analytic Hierarchy Process(AHP)

2.1.2 Establishing pairwise comparison judgment matrix and calculating the weight value

Saaty 's weight method was used. At first, every index was compared and scores were given, and scoring standard was shown in Table 1. Then every index was compared and scores were obtained.

$$R=\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{nn} \end{bmatrix} \quad (1)$$

(1) $r_{ii}=0.5, i=1,2,\cdots,n;$

(2) $r_{ij}=1-r_{ji}, i, j=1,2,\cdots,n;$

(3) $r_{ij}=r_{ik}-r_{jk}, i, j, k=1,2,\cdots,n.$

$$\begin{cases} 2a^2(n-1)\omega_1-2a^2\omega_2-2a^2\omega_3-\cdots-2a^2\omega_n+\lambda \\ =a\sum_{j=1}^{n}(r_{1j}-r_{j1}) \\ -2a^2\omega_1+2a^2(n-1)\omega_2-2a^2\omega_3-\cdots-2a^2\omega_n+\lambda \\ =a\sum_{j=1}^{n}(r_{2j}-r_{j2}) \\ \cdots\cdots\cdots\cdots\cdots\cdots \\ -2a^2\omega_1-2a^2\omega_2-2a^2\omega_3-\cdots+2a^2(n-1)\omega_n+\lambda \\ =a\sum_{j=1}^{n}(r_{nj}-r_{jn}) \\ \omega_1+\omega_2+\cdots+\omega_n=1 \end{cases} \quad (2)$$

At last, matrix was evaluated according to the established scores, and the weight of every index was got. The approximate weight of each index was

$$\overline{W_i}=\sqrt[m]{a_{i1}a_{i2\cdots}a_{im}} \quad (3)$$

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The approximate weight was treated with normalized processing according to the following formula:

$$W_i = \frac{\overline{W_i}}{\sum_{i=1}^{m} \overline{W_i}} \quad (4)$$

The weight of index referred to different scores.

Table 1: Scoring Standard Of Different Layers By AHP

Importance Scale a_{ij}	Importance degree
1	equally important
3	slightly important
5	basically important
7	really important
9	absolutely important
2,4,6,8	The middle value of two adjacent degree
countdown	If the importance ratio between element i and element j is a_{ij}, the importance ratio between element j and element ii is $a_{ji} = \frac{1}{a_{ij}}$

2.1.3 Consistency test

Consistency index

$$CI = \frac{\lambda_{\max} - m}{m-1} \quad (5)$$

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{m} \lambda_i / m \quad (6)$$

$$\lambda_i = \sum_{j=1}^{m} a_{ij} W_j / W_i \quad (7)$$

Ratio of calculation random consistency

$$CR = \frac{CI}{RI} \quad (8)$$

RI referred to average order random consistency index. Its score in different order was shown in table 2

Table 2: Average Random Consistency Index Scoring

Number	*RI*
1	0.00
2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45

If CR value was less than 0.1, you could think of the consistency of judgment matrix as good.

2.1.4 Using multiplication to calculate combination weight

Combination weight referred to coefficient obtained by weight multiplication according to the weight of each index in different layers.

2.2. Fuzzy comprehensive evaluation

Using AHP to calculate the weight of each index, it was needed to evaluate the comprehensive level of the evaluation object. Based on fuzzy set theory, Fuzzy comprehensive evaluation considered the function of every evaluating factor and made the evaluation process to the evaluation object. Owing to this method's fuzziness in classifying numbers, fuzzy mathematics' principle and methods made the evaluation results to things more reasonable and reliable. The process of Fuzzy comprehensive evaluation was shown below:

1）determining the main factors of evaluation

$$X = (x_1, x_2, \cdots, x_n) \quad (7)$$

2）using the AHP to calculate the secondary evaluation index weight set

$$W = (\omega_1, \omega_2, \cdots, \omega_n) \quad (9)$$

3）determining the level of evaluation

$$Y = (y_1, y_2, \cdots, y_n) \quad (10)$$

4）determining the standard membership degree of each

Level u

$$u = (u_1, u_2, \cdots, u_m) \quad (11)$$

5） Constructing fuzzy evaluation matrix R to the evaluation object

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix} \quad (12)$$

6）For fuzzy comprehensive membership degree set B

$$B = R \bullet u^T \quad (13)$$

7）For the total comprehensive membership degree

$$U = A \bullet B \quad (14)$$

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Comprehensive membership degree *U* was the total score obtained by fuzzy evaluation to the evaluation object and according to this total score, evaluation was made to every evaluation object.

3. MODEL CONSTRUCTION OF JUDO ATHLETE SELECTING EVALUATION BASED ON THE AHP FUZZY COMPREHENSIVE EVALUATION

3.1. Selecting The Evaluation Index And Constructing Hierarchical Level Structure

After reading a large number of literature and consulting teachers long engaged in the work of graduate enrollment in combination with my working experience for many years, the author decided to make evaluation to graduate second-round examination from the following three aspects, namely knowledge structure, scientific research ability and comprehensive quality. And every aspect was evaluated according to different evaluation indexes. At last three-layered hierarchical level structure was shown in Table 3.

Table 3: Graduate second-round evaluation index system

A level	B level	C level
Comprehensive level of graduates' attending second-round examination A	knowledge structure B1	basic knowledge C1
		academic knowledge C2
	scientific research ability B2	thinking ability C3
		research ability C4
	comprehensive quality B3	foreign language C5
		computer ability C6
		scientific research potential C7
		adaption ability C8
		language ability C9

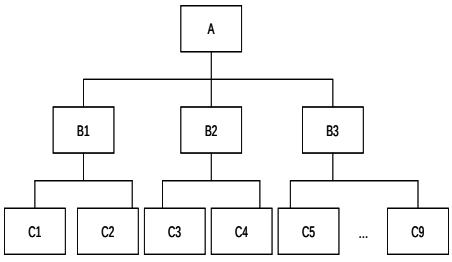

Figure 2: The hierarchical level structure

3.2. Establishing Judgment Matrix And Calculating Weight

Sati's weight method was used to establish judgment matrix of indexes in every level and the weight of every index, the results were shown below

Table 4: Judgment Matrix And Weight Of The First Level Evaluation System

A	B1	B2	B3	weight value
B1	1	1	3	0.429
B2	1	1	3	0.429
B3	0.333	0.333	1	0.142

*Table 5: **Judgment** Matrix And Weight Of The Secondary Evaluation System（Knowledge Structure）*

B1	C1	C2	weight value
C1	1	0.5	0.333
C2	2	1	0.667

Table 6: Judgment Matrix And Weight Of The Secondary Evaluation System（Scientific Research Ability）

B2	C3	C4	weight value
C3	1	1	0.5
C4	1	1	0.5

Table 7: Judgment Matrix And Weight Of The Secondary Evaluation System（Comprehensive Quality ）

B3	C5	C6	C7	C8	C9	weight value
C5	1	2	0.5	2	2	0.241
C6	0.5	1	0.333	1	1	0.124
C7	2	3	1	3	3	0.387
C8	0.5	1	0.333	1	1	0.124
C9	0.5	1	0.333	1	1	0.124

3.3 Consistency test

Formula 3 to 6 were used to calculate random consistency ratio CR value of the first level matrix and each secondary matrix. The results were shown below.

Table 8: Consistency Test Results

matrix	*CR*	Consistency results
first level matrix	0.015	satisfied
secondary matrix B1	0.020	satisfied
secondary matrix B2	0.031	satisfied
secondary matrix B3	0.028	satisfied

3.4 Using Multiplication To Calculate Combination Weight Of The Lowest Index

Combination weight of the lowest index was shown in table 9.

Table 9: Combination Weight Value Of The Lowest Index

A level	B level	C level	combination weight
comprehensive level of	knowledge structure（0.429）	basic knowledge（0.333	0.143

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graduates' attending second-round examination		)	
		academic knowledge（0.667）	0.286
	scientific research ability （0.429）	thinking ability（0.5）	0.215
		research ability（0.5）	0.215
		foreign language（0.241）	0.034
		computer ability（0.124）	0.018
	comprehensive quality（0.142）	scientific research potential（0.387）	0.055
		adaption ability（0.124）	0.018
		language ability（0.124）	0.018

3.5 The evaluation results of Fuzzy comprehensive evaluation

In the process of graduate second-round examination, the judges were composed of 5 experts, each responsible for scoring the graduate in the terms of the above 3 aspects respectively. After score conversion, 5 experts presented the accurate score of the graduate attending second-round examination. The data were shown in Table 10.

Table 10: Summary Of 5 Experts' Scoring To The Graduate Attending Second-Round Examination

evaluation index	Z1	Z2	Z3	Z4	Z5
C1	85	84	90	83	88
C2	87	86	92	85	84
C3	82	85	86	80	83
C4	78	80	83	80	82
C5	90	84	87	86	84
C6	92	88	89	82	83
C7	84	85	83	79	86
C8	88	82	86	81	84
C9	86	83	85	84	81

In scoring, 85 scores or more than 85 were considered as excellent; the score from 75 to 84 good; the score from 60 to 74 qualified; the score under 60 unqualified. The scores in Table 9 were classified and summarized according to the level. The results were shown in Table 11.

Table 11: Rating Summary Of Evaluation Score Of The Graduate Attending Second-Round Examination

evaluation index	excellent	good	qualified	unqualified
C1	3	2	0	0
C2	4	1	0	0
C3	2	3	0	0
C4	0	5	0	0
C5	3	2	0	0
C6	3	2	0	0
C7	2	3	0	0
C8	2	3	0	0
C9	2	3	0	0

According to the rating results, Fuzzy comprehensive evaluation method was used to evaluate.

1）Determining the main factors evaluated

X =(Knowledge structure, scientific research ability, comprehensive quality）

2）The weight of the secondary index

Based on the above calculation results, the weights of evaluation index set in this study were

W=（0.429, 0.429, 0.142）

3）Determining evaluation level Y：

Y= (excellent, good, qualified, unqualified)

4）Determining the standard membership U of evaluation set

u =（1/excellent，0.8/good，0.6/qualified，0.1/unqualified）

In the actual calculation, taking

$u = (1, 0.8, 0.6, 0.1)$

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5) Establishing fuzzy evaluation matrix R on the evaluation objects

From table 9, it was seen that the evaluation matrix of knowledge structure（B1）、scientific research ability （B2）and comprehensive quality （B3）as followed

$$B1=\begin{bmatrix} 3/5 & 2/5 & 0 & 0 \\ 4/5 & 1/5 & 0 & 0 \end{bmatrix}$$

$$B2=\begin{bmatrix} 2/5 & 3/5 & 0 & 0 \\ 0 & 5/5 & 0 & 0 \end{bmatrix}$$

$$B3=\begin{bmatrix} 3/5 & 2/5 & 0 & 0 \\ 3/5 & 2/5 & 0 & 0 \\ 2/5 & 3/5 & 0 & 0 \\ 2/5 & 3/5 & 0 & 0 \\ 2/5 & 3/5 & 0 & 0 \end{bmatrix}$$

6) Calculating fuzzy comprehensive membership degree u

$$\bar{u}_1 = B_1 u^T = \begin{bmatrix} 3/5 & 2/5 & 0 & 0 \\ 4/5 & 1/5 & 0 & 0 \end{bmatrix} \bullet \begin{bmatrix} 1 \\ 0.8 \\ 0.6 \\ 0.1 \end{bmatrix} = \begin{bmatrix} 0.92 \\ 0.96 \end{bmatrix}$$

$$\bar{u}_2 = B_2 u^T = \begin{bmatrix} 2/5 & 3/5 & 0 & 0 \\ 0 & 5/5 & 0 & 0 \end{bmatrix} \bullet \begin{bmatrix} 1 \\ 0.8 \\ 0.6 \\ 0.1 \end{bmatrix} = \begin{bmatrix} 0.88 \\ 0.8 \end{bmatrix}$$

$$\bar{u}_3 = B_3 u^T = \begin{bmatrix} 3/5 & 2/5 & 0 & 0 \\ 3/5 & 2/5 & 0 & 0 \\ 2/5 & 3/5 & 0 & 0 \\ 2/5 & 3/5 & 0 & 0 \\ 2/5 & 3/5 & 0 & 0 \end{bmatrix} \bullet \begin{bmatrix} 1 \\ 0.8 \\ 0.6 \\ 0.1 \end{bmatrix} = \begin{bmatrix} 0.92 \\ 0.92 \\ 0.88 \\ 0.88 \\ 0.88 \end{bmatrix}$$

7) Calculating the total comprehensive membership U

Calculating the total comprehensive membership U1, U2, U3 of evaluation objects B1, B2, B3 respectively

$$U_1 = \omega_1 \bullet \bar{u}_1 = (0.333, 0.667) \bullet \begin{bmatrix} 0.92 \\ 0.96 \end{bmatrix} = 0.946$$

$$U_2 = \omega_2 \bullet \bar{u}_2 = (0.5, 0.5) \bullet \begin{bmatrix} 0.88 \\ 0.8 \end{bmatrix} = 0.84$$

$$U_3 = \omega_3 \bullet \bar{u}_3 = (0.241, 0.124, 0.387, 0.124, 0.124) \bullet \begin{bmatrix} 0.92 \\ 0.92 \\ 0.88 \\ 0.88 \\ 0.88 \end{bmatrix} = 0.895$$

Finally calculating the total comprehensive membership U

$$\bar{u} = (U_1, U_2, U_3, U_4)$$

$$U = \omega \bullet \bar{u} = \begin{bmatrix} 0.946 \\ 0.84 \\ 0.895 \end{bmatrix} \bullet (0.429, 0.429, 0.142) = (0.406, 0.360, 0.127)$$

According to membership degree maximum principle, evaluation results were presented

Analysis to evaluation results showed that due to $u_1 = 0.406$ (this value was the biggest), the result of second-round examination of the graduate was “excellent”.

4. CONCLUSION

This study combined Analytic Hierarchy Process (AHP) and Fuzzy comprehensive evaluation methods to establish the evaluation system model of graduate second-round examination. AHP calculated the weights of each evaluation index from the global perspective while Fuzzy comprehensive evaluation method used the fuzzy mathematics to make comprehensive evaluation to the graduate attending second-round examination. This method quantified the evaluation indexes and got rid of the deficiency of the traditional qualitative evaluation method. The evaluation results were more accurate and reasonable. At the same time, this method made up for insufficient evaluation in the process of graduate second-round examination, so it was worthwhile to popularize it in graduate second-round examination and other secondary interviews.

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