Research on Evaluation of Employment Quality of Higher Vocational Students Based on Multi-hierarchal Gray Systematic Evaluation Method

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Abstract
The employment quality of higher vocational students reflects the school's operation quality. In order to overcome ambiguity and uncertainty in the evaluation of the employment quality of higher vocational students, the multi-hierarchal gray systematic evaluation method is applied for evaluation research. The evaluation indicator system for the employment quality of higher vocational students is built around the government level, the graduate level and the social level. The weight coefficients of indicators at all levels are determined using the analytic hierarchy process, and the gray evaluation matrix of indicators at all levels is obtained in combination with the gray evaluation method. The evaluation results of the employment quality of students from higher vocational colleges are obtained through fuzzy operation. This method can help higher vocational colleges understand the overall situation of the employment quality of their students as well as provide theoretical and practical references for higher vocational colleges to improve the employment quality of graduates.

Index Terms—Multi-hierarchal gray systematic evaluation method; higher vocational students; evaluation on employment quality.

1.INTRODUCTION

With the promulgation of the Implementation Scheme for National Vocational Education Reform issued by the State Council, the categorization of vocational colleges has become clearer, and the employment quality of vocational colleges has also become an important indicator for the development of vocational education. It is an issue that the vocational education personnel are constantly thinking about, on the ways to achieve high-quality employment for graduates from vocational colleges on the basis of ensuring employment. It is also an issue worthy of in-depth discussion, on the ways to evaluate the employment quality of graduates from vocational colleges more objectively.

Through literature retrieval, it is not difficult for us to find that the "employment quality of college students" has long been a hot topic in the academic circle. There are dozens to more than a hundred articles discussing this topic every year, which, from another perspective, also confirms the importance of the employment quality of college students. Judging from the evaluation of the "employment quality of college students", the amount of literature in this aspect has decreased sharply, which indicates that there are more qualitative literature but fewer articles on quantitative research on the topic of "employment quality of college students". However, quantitative research is an important method for evaluating the "employment quality of college students". The representative pieces of literature are as follows: Liang Guanghua [1] researched the optimization of

S. A. R. Khan et al. (Eds.): ICMSSE 2022, AHCS 12, pp. 213–219, 2023.
https://doi.org/10.2991/978-94-6463-056-5_30

evaluation on the employment quality of undergraduates from the application-oriented institutions; Liu Yang [2] pointed out that higher requirements have been proposed for the comprehensive quality of college students under the new "double-cycle" development pattern, and the coupling forces of the government, universities, enterprises, and college students will be fully exerted to continuously improve the employment quality of college students; Hu Siwen [3] built the evaluation system for the employment quality of petroleum college students using the analytic hierarchy process; Huang Jing [4] evaluated the characteristics and quality of the employment structure of college students in this province based on the empirical survey of 2015 graduates from 47 colleges and universities. The evaluation of the employment quality of college students is analyzed in the above literature, which also offers certain ideas for the research of this topic.

Judging from the research object, most of the above researches are centered on the employment quality of institutions, with less analysis on that of the higher vocational colleges. Judging from the method of use, most achievements are centered on qualitative analysis; there is little concrete data to quantitatively describe and evaluate the employment quality of college students. Based on this, the multi-hierarchal gray systematic evaluation method is applied to analyze and evaluate the employment quality of higher vocational colleges in this paper, which plays a certain role in a theoretical and practical guide for improving the employment quality.

2.MULTI-HIERARCHAL GRAY EVALUATION METHOD

The analytic hierarchy process is a systematic and hierarchical analysis method that combines qualitative and quantitative analyses. A stepped indicator system model is established to simplify the complicated system model, and the relative importance of the indicators can be fully considered. The basic principle of the gray evaluation method is to process the scattered evaluation information of multiple evaluation experts into a weight vector that describes the degree of different gray classes. On this basis, the uniformization treatment is performed to obtain the comprehensive evaluation value of the evaluated object. The multi-hierarchal gray evaluation method [5] combines the analytic hierarchy process and the gray evaluation method, which meets the requirements for the evaluation of the complicated system. The evaluation process can be carried out in steps, and the evaluation result of the previous process can be used as the input data for the evaluation of the next process. Not only can it make up for the disadvantages of the analytic hierarchy process, but it can also effectively utilize the gray system theory to analyze the advantages of qualitative indicators.

3.PROCESS OF MULTI-HIERARCHAL GRAY EVALUATION

3.1.Establish an evaluation indicator system

The evaluation indicator system is the basis for evaluating the evaluation object, and is a set of various factor indicators that affect the evaluation object. The factor indicators in the set are broken down into several levels from the top to the bottom according to different attributes. All factor indicators in the same layer effect and be subordinate to a certain factor indicator in the upper layer, and each factor indicator in the same layer dominates and is affected by the corresponding factor indicator in the next layer. The evaluation indicator system U is as follows:

Target layer: U

The comprehensive indicator layer is: $\{U_1, U_2, \cdots, U_x\}$

The project indicator layer is: $\{U_{x1}, U_{x2}, \cdots, U_{xy}\}$

The project sub-indicator layer is: $\{U_{xy1}, U_{xy2}, \cdots, U_{xyz}\}$

Where: U_{xy} - yth project indicator under the xth comprehensive indicator, U_{xyz} - zth project indicator in the yth project indicator under the xth comprehensive indicator.

3.2.Determine the indicator weight with the analytic hierarchy process

(1) Construct a numerical judgment matrix

In the analytic hierarchy process, the relative importance between factors in pairs at each level is qualitative. The T.L. saaty 1-9 scale method is used to transform qualitative evaluation into quantitative evaluation, and the values are used to measure the relationship between various relative importance. This is done so as to construct a judgment matrix.

(2) Calculate the indicator weight

After determining the judgment matrix A, use the Matlab software to solve the maximum eigenvalue λ_{max} and its corresponding eigenvector V, and normalize the eigenvector V to obtain the indicator weight W.

(3) Check the consistency

Calculate the consistency indicator $CI = (\lambda_{max} - 1)/(n-1)$ and the random consistency ratio $CR = CI/RI$. Among them, RI is the average consistency indicator of the judgment matrix. Judge the size of CR. If $CR < 0.1$, the consistency is met. Otherwise, the value of the judgment matrix should be adjusted until the consistency is satisfactory.

3.3.Develop the scoring level standards of evaluation indicators

Develop the scoring level standards, and quantify the evaluation indicator U_{ij}. The conventional four-level comment system is adopted in this paper. Various evaluation indicators are divided into four levels, i.e., "excellent, good, average and poor", and the corresponding scores are 4, 3, 2 and 1 point respectively. The indicator level is between two adjacent levels, and the corresponding scores are 3.5, 2.5 and 1.5 points.

3.4.Organize scoring to obtain the evaluated sample matrix

Assuming that there are k evaluators to score the indicator U_{xyz}, and the serial number of the evaluator is s, $s = 1,2,\cdots,k$, then the score given for the indicator U_{xyz} by the sth evaluator is recorded as r_{xyzs}, and the evaluated sample matrix $R^{(xy)}$ of the y th project indicator under the xth comprehensive indicator can be obtained;

$$R^{(xy)}=\begin{bmatrix} r_{xy11} & r_{xy12} & \cdots & r_{xy1k} \\ r_{xy21} & r_{xy22} & \cdots & r_{xy2k} \\ \vdots & \vdots & \vdots & \vdots \\ r_{xyz1} & r_{xyz2} & \cdots & r_{xyzk} \end{bmatrix}$$

3.5.Determine the evaluation gray class

Analyze the scoring level standard of the analysis indicator U_{xyz}, and determine the level of gray class. The gray number of evaluation gray class $e, e = 1,2,\cdots,g$ and the whitenization weight function of the gray class $f_e(x)$. $f_e(x)$ can quantitatively describe the degree to which a certain evaluation object belongs to a certain gray class, i.e., the relationship of changes with the size of the evaluated indicator or sample point value.

3.6.Calculate the gray evaluation coefficient

For the evaluation indicator U_{xyz}, the gray evaluation coefficient belonging to the eth evaluation gray class is recorded as P_{xyze}, and

$$P_{xyze} = \sum_{s=1}^{k} f_e(r_{xyzs}) \quad (1)$$

The total gray evaluation coefficient belonging to various evaluation gray classes is recorded as P_{xyz}, and

$$P_{xyz} = \sum_{e=1}^{g} P_{xyze} \quad (2)$$

3.7.Calculate the gray evaluation weight vector and weight matrix

For the evaluation indicator U_{xyz}, all evaluators record the gray evaluation weight belonging to the e gray class as d_{xyze}, and: $d_{xyze} = P_{xyze}/P_{xyz}$. The gray evaluation weight vector $d_{xyz} = (d_{xyz1}, d_{xyz2}, \cdots, d_{xyze})$ of the evaluation indicator U_{xyz} for each gray class.

After integrating the gray evaluation weight vector of indicator U_{xyz} to which U_{xy} belongs for each evaluation gray class, the gray evaluation weight matrix D_{xy} of indicator U_{xyz} to which U_{xy} belongs for each evaluation gray class is obtained:

$$D_{xy} = \begin{bmatrix} d_{xy1} \\ d_{xy2} \\ \cdots \\ d_{xyz} \end{bmatrix} = \begin{bmatrix} d_{xy11} d_{xy12} \cdots d_{xy1g} \\ d_{xy21} d_{xy22} \cdots d_{xy2g} \\ \vdots \quad \vdots \quad \cdots \quad \vdots \\ d_{xyz1} d_{xyz2} \cdots d_{xyzg} \end{bmatrix}$$

3.8.Perform comprehensive evaluation of U_{xy}

Comprehensive evaluation of U_{xy} is performed through fuzzy operation, the evaluation result is recorded as C_{xy}, and

$$C_{xy} = W_{xy} \circ D_{xy} = [c_{xy1}, c_{xy2}, \cdots, c_{xyg}] \quad (3)$$

3.9.Perform comprehensive evaluation of U_x

The gray evaluation weight matrix D_x : $D_x = [C_{x1}, C_{x2}, \cdots, C_{xy}]^T$ of indicator U_{xy} to which U_x belongs for each evaluation gray class is obtained through the comprehensive evaluation result C_{xy} of U_{xy}. Comprehensive evaluation of U_x is performed through fuzzy operation, the evaluation result is recorded as C_x, and

$$C_x = W_x \circ D_x = [c_{x1}, c_{x2}, \cdots, c_{xg}] \quad (4)$$

3.10.Perform comprehensive evaluation of U

The gray evaluation weight matrix D : $D = [C_1, C_2, \cdots, C_x]^T$ of indicator U_x to which U belongs for each evaluation gray class is obtained through the comprehensive evaluation result C_x of U_x. Comprehensive evaluation of U is performed through fuzzy operation, the evaluation result is recorded as C, and

$$C = W \circ D = [c_1, c_2, \cdots, c_g] \quad (5)$$

4.PROCESS OF MULTI-HIERARCHAL GRAY EVALUATION ON EMPLOYMENT QUALITY OF COLLEGE STUDENTS

4.1.Establish the evaluation indicator system for the employment quality of college students

After having extensively collected opinions from the Enrollment and Employment Office (Student Work Department), Youth League Committee, secondary colleges, internal students, graduates and employers, three aspects, i.e., government-level evaluation, graduate-level evaluation and social-level evaluation, are determined as the comprehensive indicator layer of the evaluation system. In actuality, the subset of each factor of the comprehensive indicator layer also includes the corresponding factor, i.e., the corresponding project indicator layer. Through informal discussion among the experts, six factors, including employment opportunities, are determined as the project indicator layer, and 17 factors, including the initial employment rate of the graduates, are determined as the project sub-indicator layer according to the statistical results. The evaluation system is as shown in Figure 1.

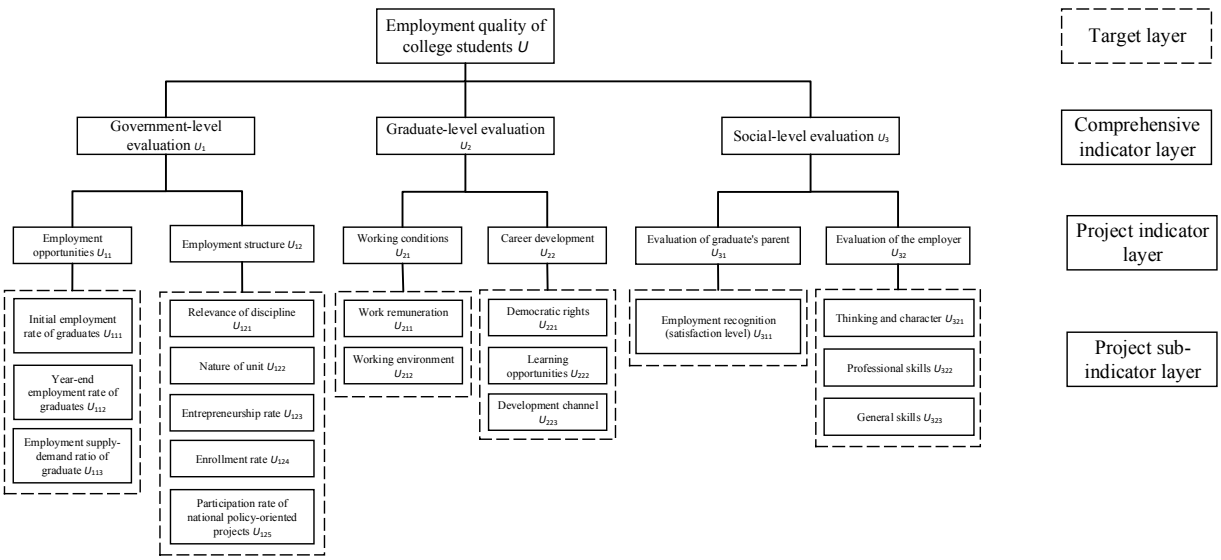

Figure 1 Evaluation indicator system for employment quality of college students

4.2.Determine the indicator weight with the analytic hierarchy process

The literature [6] is quoted and the analytic hierarchy process adopted to determine the weight of the evaluation indicator of each layer so as to determine the weights of the comprehensive indicator layer, the project indicator layer and the project sub-indicator layer. The weight set of the comprehensive indicator layer is $W = (0.3\ \ 0.4\ \ 0.3)$; the weight sets of various project indicator layer are $W_1 = (0.5\ \ 0.5)$, $W_2 = (0.625\ \ 0.375)$, $W_3 = (0.2\ \ 0.8)$; and the weight sets of various project sub-indicator layers are $W_{11} = (0.1\ \ 0.26\ \ 0.64)$, $W_{12} = (0.273\ \ 0.091\ \ 0.091\ \ 0.273\ \ 0.273)$, $W_{21} = (0.5\ \ 0.5)$, $W_{22} = (0.1\ \ 0.26\ \ 0.64)$, $W_{32} = (0.1\ \ 0.26\ \ 0.64)$.

4.3.Organize scoring to obtain the evaluated sample matrix

Five experts from the education system were gathered to score the project sub-indicators under the project indicator layer corresponding to the government-level evaluation indicator layer according to the scoring level standard; Five graduates were gathered to score the project sub-indicators under the working conditions and career development according to the scoring level standard; the parents and employers of the five graduates scored the project sub-indicators under the social-level evaluation respectively. The corresponding scores of excellent, good, average and poor are 4, 3, 2 and 1 point respectively. The corresponding scores between two adjacent levels are 3.5, 2.5 and 1.5 points. The evaluated sample matrix $R^{(11)}$, $R^{(12)}$, $R^{(21)}$, $R^{(22)}$, $R^{(31)}$ and $R^{(32)}$ of six project indicator layers are obtained:

$$R^{(11)} = \begin{bmatrix} 3.5 & 4.0 & 3.5 & 3.5 & 3.5 \\ 3.0 & 3.5 & 3.5 & 3.0 & 3.0 \\ 3.0 & 3.5 & 3.0 & 3.0 & 3.5 \end{bmatrix}$$

$$R^{(12)} = \begin{bmatrix} 3.0 & 2.5 & 3.5 & 3.0 & 3.0 \\ 3.5 & 3.0 & 3.0 & 3.5 & 3.5 \\ 1.5 & 2.0 & 3.0 & 1.5 & 2.0 \\ 3.0 & 2.5 & 2.5 & 2.5 & 2.0 \\ 2.5 & 2.0 & 2.0 & 1.5 & 2.0 \end{bmatrix}$$

$$R^{(21)} = \begin{bmatrix} 3.5 & 3.0 & 3.0 & 3.5 & 4.0 \\ 3.0 & 3.0 & 2.5 & 3.0 & 3.5 \end{bmatrix}$$

$$R^{(22)} = \begin{bmatrix} 3.5 & 3.5 & 3.0 & 3.5 & 3.5 \\ 3.0 & 3.5 & 3.5 & 3.0 & 3.0 \\ 3.0 & 2.5 & 3.0 & 3.0 & 3.5 \end{bmatrix}$$

$$R^{(31)} = [4.0 \quad 3.5 \quad 3.5 \quad 4.0 \quad 4.0]$$

$$R^{(32)} = \begin{bmatrix} 3.5 & 4.0 & 3.0 & 3.5 & 3.0 \\ 3.5 & 3.0 & 3.0 & 3.0 & 2.5 \\ 3.0 & 3.0 & 3.5 & 3.0 & 3.0 \end{bmatrix}$$

4.4.Determine the evaluation gray class

Considering 4 evaluation gray classes, the serial number of the evaluation gray class is set as e, that is to say, e=1, 2, 3, 4. They corresponds to four levels, i.e., "excellent", "good", "average" and "poor" respectively. The corresponding gray number and whitenization weight function are as follows: First gray class "excellent" (e=1), gray number $\otimes_1 \in [4.0, \infty)$, the whitenization weight function is $f_1(x)$ (as shown in Figure 2 (a)); Second gray class "good" (e=2), gray number $\otimes_2 \in [0,3.0,6.0)$, the whitenization weight function is $f_2(x)$ (as shown in Figure 2 (b)); Third gray class "average" (e=3), gray number $\otimes_3 \in [0,2.0,4.0)$, the whitenization weight function is $f_3(x)$ (as shown in Figure 2 (c)); Forth gray class "poor" (e=4), gray number $\otimes_4 \in [0,1.0,2.0)$, the whitenization weight function is $f_4(x)$ (as shown in Figure 2 (d)).

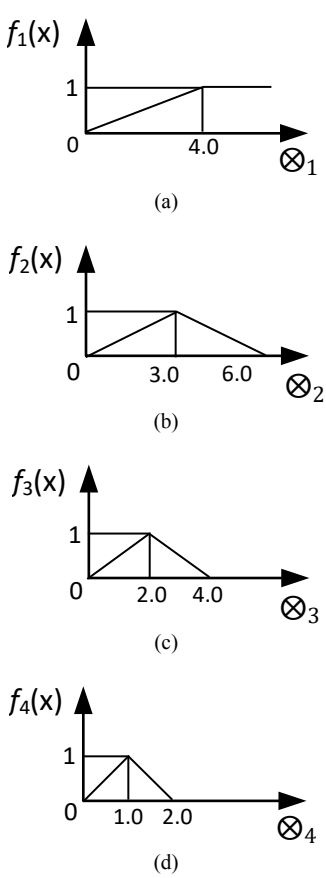

Figure 2 Schematic diagram for whitenization weight function of each white class

When e=1, the 1st gray class is "excellent", set the gray number $\otimes_1 \epsilon [0,4.0,\infty)$, and record the whitenization weight function of the class as $f_1(x)$,

$$f_1(x) = \begin{cases} \frac{1}{4}x & (x\epsilon[0,4.0)) \\ 1 & (x\epsilon[4.0,\infty)) \end{cases} \tag{6}$$

When e=2, the 2nd gray class is "good", set the gray number $\otimes_2 \epsilon [0,3.0,6.0)$, and record the whitenization weight function of the class as $f_2(x)$,

$$f_2(x) = \begin{cases} \frac{1}{3}x & (x\epsilon[0,3.0)) \\ -\frac{1}{3}x + 2 & (x\epsilon[3.0,6.0)) \end{cases} \tag{7}$$

When e=3, the 3rd gray class is "average", set the gray number $\otimes_3 \epsilon [0,2.0,4.0)$, and record the whitenization weight function of the class as $f_3(x)$,

$$f_3(x) = \begin{cases} \frac{1}{2}x & (x\epsilon[0,2.0)) \\ -\frac{1}{2}x + 2 & (x\epsilon[2.0,4.0)) \end{cases} \tag{8}$$

When e=4, the 4th gray class is "poor", set the gray number $\otimes_4 \epsilon [0,1.0,2.0)$, and record the whitenization weight function of the class as $f_4(x)$,

$$f_4(x) = \begin{cases} x & (x\epsilon[0,1.0)) \\ -x + 2 & (x\epsilon[1.0,2.0)) \end{cases} \tag{9}$$

4.5.Calculate the gray evaluation coefficient

Since e=1, 2, 3, 4, the gray evaluation weight vector of the evaluation indicator U_{xyz} for each gray class $d_{xyz} = (d_{xyz1}, d_{xyz2}, d_{xyz3}, d_{xyz4})$. For the evaluation indicator U_{111}, the gray evaluation coefficient belonging to the e th evaluation gray class is: e=1, $P_{1111} = \sum_{s=1}^{5} f_1(r_{111s}) = f_1(3.5) + f_1(4) + f_1(3.5) + f_1(3.5) + f_1(3.5) = 0.875 + 1 + 0.875 + 0.875 + 0.875 = 4.5$. Similarly, e=2, $P_{1112} = 4$; e=3, $P_{1113} = 1$; e=4, $P_{1114} = 0$, and the total gray evaluation coefficient of the evaluation indicator U_{111} belonging to each evaluation gray class is $P_{111} = \sum_{e=1}^{4} P_{111e} = 9.5$.

4.6.Calculate the gray evaluation weight vector and weight matrix

For the evaluation indicator U_{111}, all evaluators record the gray evaluation weight belonging to the 1 gray class as d_{1111}, and: $d_{1111} = P_{1111}/P_{111} = 0.4737$. It can be concluded that the gray evaluation weight vector of each gray class to which the evaluation indicator U_{111} belongs is: $d_{111} = (d_{1111}, d_{1112}, d_{1113}, d_{1114}) = (0.4737,0.4211,0.1053,0)$. Similarly, the following can be obtained: d_{112}, d_{113} and d_{114}. After integrating the gray evaluation weight vector of indicator U_{11z} for the evaluation gray class, the gray evaluation weight matrix D_{11} of indicator U_{11z} to which U_{11} belongs for each evaluation gray class is obtained.

$$D_{11} = \begin{bmatrix} 0.4737 & 0.4211 & 0.1053 & 0 \\ 0.3750 & 0.4375 & 0.1875 & 0 \\ 0.3750 & 0.4375 & 0.1875 & 0 \end{bmatrix}$$

Likewise, D_{12} , D_{21} , D_{22} , D_{31} and D_{32} can be obtained.

4.7.Perform comprehensive evaluation of U_{xy}

For U_{11}, the comprehensive evaluation result C_{11} is: $C_{11} = W_{11} \circ D_{11} = (0.3750,0.4375,0.1875,0)$. Similarly, C_{12}, C_{21}, C_{22}, C_{31} and C_{32} can be obtained.

4.8.Perform comprehensive evaluation of U_x

The gray evaluation weight matrix D_1 , $D_1 = [C_{11}, C_{12}]^T$ of indicator U_{11} to which U_1 belongs for each evaluation gray class is obtained through the comprehensive evaluation result C_{11} of U_{11} . Comprehensive evaluation of U_1 is performed, and the evaluation result C_1 is recorded as: $C_1 = W_1 \circ D_1 = [0.3750,0.4375,0.273,0.091]$ Similarly, C_2 and C_3 can be obtained.

4.9.Perform comprehensive evaluation of U

The gray evaluation weight matrix D , $D = [C_1, C_2, C_3]^T$ of indicator U_1 to which U belongs for each evaluation gray class is obtained through the comprehensive evaluation result C_1 of U_1 . Comprehensive evaluation of U is performed, and the comprehensive evaluation result is $C = W \circ D = [0.4,0.4,0.273,0.091]$.

The evaluation result weight vector C is only a description of the degree of the evaluation object's gray class. In order to avoid information distortion, uniformization treatment should be performed, and each gray level should be assigned according to the gray level. Let the gray level vector $\mathrm{V} = [4,3,2,1]$ and obtain comprehensive evaluation S: $S = CV^T = 3.437$. The results show that the employment quality of the students of this college is evaluated as good.

5. CONCLUSION

The analytic hierarchy process can break down the complicated target layer and determine the importance of each indicator, making the evaluation system fairer and more objective. The gray evaluation method assigns the corresponding values to the qualitative indicators according to the division level so as to improve the reliability and accuracy of the evaluation system. The combination of the two achieves objective and an accurate evaluation of the employment quality of higher vocational colleges. This method can help higher vocational colleges to understand the overall situation of the employment quality of their students through data analysis, analyze and find the weak links of the college in the early employment work in a targeted manner as well as provide the basis and reference for further formation of a large employment system that can be checked, modified and controlled.

ACKNOWLEDGMENT

This paper includes the phased achievements of the research subject of employment and entrepreneurship of college graduates in Jiangsu - Research on Evaluation and Application of Employment Attitude of College Students Based on Analytic Hierarchy Process and Gray System Theory-Taking Higher Vocational College in Jiangsu as an Example (subject number: JCKT-C-2019404).

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