A Performance Appraisal of Teachers in Higher Vocational Colleges Based on Entropy Weight and Grey Correlation Degree

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Abstract: Teachers' performance appraisal of higher vocational colleges is a comprehensive evaluation of teachers' teaching, scientific research and social services, It is an important means of standardized management in higher vocational colleges. Reasonable and efficient performance appraisal can effectively mobilize the enthusiasm of teachers, improve the comprehensive quality of teachers, and optimize the efficiency of higher vocational colleges. Based on the relevant theory, this paper constructs a performance appraisal model of Higher Vocational College Teachers Based on entropy weight and grey correlation degree, which eliminates the influence of small sample and subjectivity on the system and reduces the difficulty of operation. It provides a new idea about teachers' performance appraisal.

1. Introduction

In 2016, the Ministry of education of the people's Republic of China issued the "guiding opinions of the Ministry of education on deepening the reform of University Teachers' assessment and evaluation system", which pointed out: "the assessment and evaluation policy has an overall and fundamental impact on promoting teaching reform, improving the quality of Education, adhering to the correct scientific research orientation, promoting the transformation of scientific research achievements, carrying out innovation and entrepreneurship and social services in Colleges and universities in the new era." As an important part of higher education, higher vocational colleges' talent training mode is different from undergraduate and graduate education. How to choose a targeted performance appraisal schemes to truly reflect the working state of higher vocational teachers and improve the efficiency of higher vocational colleges has become an important problem to be solved.

The construction of performance appraisal system is the premise of performance appraisal. Yue Yuan [1] (2018) thinks that the establishment of performance appraisal system should be based on key performance indicators; Zhongnian Zhang [2] (2003) thinks that teacher appraisal should follow the principles of consistency of subject and object, combination of qualitative and quantitative; Man Shi [3] (2018) points out that the current evaluation system design of Higher Vocational Colleges tends to ignore the subjective feelings, and it is difficult to mobilize the enthusiasm for teachers. The key of performance appraisal is to choose the right method. The common methods include key performance index method, analytic hierarchy process, parallel Scorecard and so on. Huiting Hu [4] (2017) evaluated the teaching quality of foreign teachers based on the method of key performance indicators. Yuan Li [5] (2020) uses parallel scorecard to conduct performance appraisal from four perspectives of customer, finance, internal operation, learning and growth; Leihong Zhang [6] (2019) uses the process of "AHP empowerment calculation of development level" to assess the scientific research level of efficient teachers. Shaobo Qi [7] (2018) and others have similar studies. The above methods have their own advantages and disadvantages in the efficient performance appraisal. More

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scholars choose to use one or more evaluation methods based on the actual situation of the universities.

2. Theoretical basis

2.1 Entropy method

Entropy method is a kind of weighting method to determine the weight of indicators in the system by examining the degree of variation between samples. It is generally believed that the more discrete the data between different samples of the same indicator in the system, the more information it can provide, and the more important it is in the system. The larger the weight is, and vice versa.

2.1.1 Construction of initial evaluation system matrix

Suppose the teachers' performance appraisal system of higher vocational colleges is set A, $A=\{a_1,...,a_i,...,a_m\}$, and the sample under investigation is set B, $B=\{b_1,...,b_j,...,b_n\}$, the initial evaluation system matrix C can be constructed: $C=(c_{ij})_{m\times n}$.

2.1.2 Dimensionless processing and coordinate translation

In general, there will be data type inconsistency and dimensional inconsistency in matrix C. so dimensionless processing must be carried out. In addition, "0.0001" is added to the processed result in order to avoid the phenomenon that the processed result is zero, which causes calculation chaos. And that forms the matrix D, $D = (D_{ij})_{m\times n}$. The details are as follows.

$C_j=(C_j-C_{min})/ (C_{max}-C_{min})+0.0001$……...If the index is a positive indicator

$C_j=(C_{max}-C_j)/ (C_{max}-C_{min})+0.0001$……..... If the index is a negative indicator

In order to ensure the reasonable distribution of matrix D, the matrix D is normalized to form the matrix E, $E=(e_{ij})_{m\times n}$, and the processing method is $e_{ij=}d_{ij}/\sum d_{ij}$.

2.1.3 Calculation of entropy and information utility

According to the entropy calculation formula: $f_j=[-1/\ln(\alpha)]\sum[e_{ij}\times\ln(e_{ij})]$, The entropy of the j th indicator can be measured (f_j), where "α" is the number of samples. Entropy $f \in [0,1]$. If f is 1, it means that the index values in the evaluation index are completely consistent, that is, the degree of data dispersion is 0, so the information can not be provided. According to the principle of entropy method, it shows that it is not important in the system. On the contrary, if f is 0, the index is very important in the system. In this paper, we introduce the information utility degree "g", g = 1-f. if we make this transformation, we can ensure that the information utility degree is proportional to the importance of the index.

2.1.4 Weight determination

According to the formula: $h_{j=}g_j/\sum g_j$, the weight of each index in the index system can be determined [8] [9].

2.2 Grey correlation degree

The degree of gray correlation judges whether the sequence is closely related by comparing the similarity of the geometric shapes of the sequence curves in the system. The closer the curves are, the greater the correlation between the corresponding sequences, and vice versa. Then determine the main relationship between the various factors in the system, and find out the significant influence factors. In addition, the gray correlation degree has the characteristic of "overcoming the influence of small samples on the system".

2.2.1 Determination of reference sequence

Based on the construction of the initial evaluation system matrix C (the same as the matrix C of entropy method), the reference sequence (usually use the optimal sequence) which can reflect the behavior characteristics of the evaluation system is determined. In addition, the sequence of

comparison to be investigated should be made clear

2.2.2 Dimensionless treatment

In this paper, “initial valued method” is selected for dimensionless processing. The idea of “initial valued method” is to divide all data onto matrix C by the first data onto corresponding column to form matrix “K”. $K_{ij}=C_{ij}/C_{i1}$.

Determine the row difference of matrix K, Two level maximum difference, Two level minimum difference the row difference of matrix K:$\Delta_q(p)=|K_{reference}(p)-K_{compare}(p)|$,

In the above equation, $K_{reference}(p)$ is the reference sequence, $K_{compare}(p)$ is the comparison sequence.

Two level minimum difference: $\Delta_{min}=\min_i \min_p \Delta_q(p)$

Two level maximum difference: $\Delta_{max}=\max_i \max_p \Delta_q(p)$

2.2.3 Calculation of correlation coefficient and grey correlation degree

Correlation coefficient: $R=(\Delta_{min}+S\Delta_{max})/(\Delta_{ij}+S\Delta_{max})$, “S” is the resolution coefficient, $S\in(0,1)$, usually take 0.5.

Weighted grey relational degree: $T=\sum(R\times h)$[10][11], “H” is the weight, which can be calculated by entropy method.

3. Case analysis

3.1 Establishment of index system

Table 1 performance appraisal indexs system of teachers in Higher Vocational Colleges

First-level indicators	second-level indicators	third-level indicators	Description of Third-level indicators
performance evaluation of teachers in Higher Vocational Colleges	talent training	I1	Be able to combine students' learning situation and innovate teaching methods(such as flipping class,spoc,mooc,etc.)
		I2	Master the concept and technology of information-based teaching, and introduce information-based teaching into the classroom
		I3	Awards of "teaching", "innovation , entrepreneurship" and "skills competitions" at municipal level or above (including industry associations)
		I4	Guide the students to participate in all kinds of competitions at or above the municipal level (including industry associations)
		I5	Guide students' "graduation thesis", "graduation design" , "social practice projects"
		I6	Completion of rated class hours in the semester
		I7	Construction of "teaching team", "excellent course" and "specialty group" at all levels
		I8	Are there any complaints from students or their parents this semester? Are there any teaching accidents?
		I9	Guide students to obtain "1 + X certificate"
	scientific research	I10	Patent applications
		I11	Papers published, including retrieved by EI / SCI / CSSCI / SSCI / SCIE / PKU / general journals
		I12	Participate in the horizontal and vertical topics of all levels and the publication of articles in regular newspapers
		I13	Scientific research competitions and awards at municipal level or above (including industry associations)
		I14	"Writing monographs"," general textbooks", "digital textbooks"," online courses" or" translating foreign academic monographs"
	social services	I15	Organization and training of "vocational skill appraisal" and other social training or social services
		I16	Promoting cooperation between schools and enterprises
		I17	Provide or recommend internships and employment for students
		I18	Assisting schools and enterprises to implement "New Apprenticeship System for enterprises"
		I19	Assist enterprises to operate and make profits (including" product design", "marketing promotion", "management system reform", etc.)
	teacher development	I20	"Teachers' educational background promotion ", "teachers' degree promotion" and" teachers' participation" in various levels of training
		I21	Teachers' practices in Enterprises
		I22	Awards above municipal level (excluding teaching and Research)
		I23	Work outside of teaching (includes instructor, head teacher, psychological consultation teacher, association instructor and so on.)
		I24	Status of obtaining intermediate certificates or advanced certificates

It is generally believed that colleges and universities can be regarded as a social organization providing three different outputs of teaching, scientific research , social services. Teachers are the main body to realize the three outputs of colleges and universities. Based on this, referring to the performance appraisal system of college teachers constructed by Yingwan Huang [12] (2016), and combined with the characteristics of vocational colleges, this paper analyzes the problems from talent training, scientific research, social services and teacher development. The system consists of three layers and 24 indicators. See Table 1 for details. It is worth noting that except for I8, other indicators of this index system belong to non quantitative indicators, and the weight of indicators and assessment score should be determined by combining with subjective methods such as brainstorming method or expert opinion method. After the comprehensive comparison of the advantages and disadvantages of each subjective method and the applicable conditions, the expert opinion method is finally adopted for further research.

3.2 Weight determination

According to the procedure of expert opinion law, A total of five experts were hired (Among them, one expert is from an enterprise, three are from a higher vocational college, and one is from a university. All five experts have senior titles) .According to the evaluation system, each expert scored three teachers A, B and C which from a vocational college, The score of each index is controlled between 1 to 10[2]. Finally, the initial weight matrix of entropy method is constructed based on average score of five experts.

The weight of each index is calculated based on the principle of entropy method. Because the number of samples in this paper is 3, so "α" in the entropy calculation formula is 3, and the weight calculation results are shown in Table 2 ,table 3.

Table 2 Weight of second-level indicators of teacher performance assessment evaluation indexs system in higher vocational colleges

talent training	scientific research	social services	teacher development
0.170	0.635	0.138	0.057

Table 3 Weight of third-level indicators of teacher performance assessment evaluation indexs system in higher vocational colleges

third-level indicators	weight	third-level indicators	weight	third-level indicators	weight	third-level indicators	weight
I1	0.002	I7	0.001	I13	0.154	I19	0.005
I2	0.001	I8	0.139	I14	0.112	I20	0.001
I3	0.002	I9	0.006	I15	0.071	I21	0.006
I4	0.003	I10	0.042	I16	0.013	I22	0.009
I5	0.008	I11	0.125	I17	0.005	I23	0.022
I6	0.007	I12	0.203	I18	0.044	I24	0.019

3.3 Calculation of Grey Relation

In this paper, full mark sequence is selected as the reference sequence of the system, That is to say, it is assumed that all indicators are scored 10 points. In addition, two other sequences are selected as supplementary reference sequences. One column is the "qualified sequence", assuming that all indicators are scored 6 points (I8 indicators is scored 7 points). The "qualified sequence" is equivalent to virtual out a new teacher, and the teacher's score of each index is 6 points (I8 index is 7 points). The value of grey correlation degree between "qualified sequence" and "full score sequence" is regarded as the qualified standard of teachers' performance appraisal. If the grey

[2]The evaluation standard of I8 index is: if there is no complaint or teaching accident, scored 10 points; If there is only one complaint, scored 7 points; If there is only one "level 1 teaching accident", scored 5 points; If there is only one "level 2 teaching accident", scored 3 points; If there is only one "level 3 teaching accident", scored 1 point; if there are two or more teaching accidents/ complaints ,scored 1 points.

correlation degree between teachers' scoring sequence and “full score sequence” is greater than the value, the teacher is qualified. If it is less than the value, the teacher is unqualified.

The other column is “excellent sequence ”, assuming that all indexes are scored 8 points (I8 index scored 10 points), and the grey correlation value between “excellent sequence” and “full score sequence” is excellent standard.

Through calculation, the grey correlation degree values of the scoring sequence and “full score sequence” of A, B and C are 0.401, 0.598 and 0.578, the qualified standard is 0.539, and the excellent standard is 0.735. See Table 4 for details.

3.4 Evaluation results and description

First, the gray correlation value are taken as the assessment results of the three between the score sequence of A, B , C and the full mark sequence. It can be considered that the assessment results of three people: B >C> A.

Second, according to the gray correlation degree of the “qualified sequence” and the “excellent sequence” with the “full score sequence”, the teacher evaluation standard can be divided. If the value of the teacher evaluation result is greater than the gray correlation degree of the “excellent sequence” , the evaluation result can be considered as “excellent”. The gray correlation degree is greater than the correlation degree of the “qualified sequence”, and the evaluation result can be considered as qualified. If the correlation degree is less than the correlation degree of the “qualified sequence”, the evaluation is considered unqualified. According to the results calculated in Table 4, this teacher assessment can be divided into three levels, See Table 5 for details. Comparing the assessment results of A, B and C with Table 5, it can be considered that A is unqualified, and B and C are qualified.

Table 4 Grey correlation coefficient and grey correlation degree of performance appraisal of A, B and C

third-level indicators	Correlation coefficient					Weights	Grey correlation				
	A	B	C	Qualified reference	Excellent reference		A	B	C	Qualified reference	Excellent reference
M1	0.63	0.73	0.81	0.529	0.692	0.002	0.00	0.00	0.00	0.001	0.001
M2	0.67	0.84	0.69	0.529	0.692	0.001	0.00	0.00	0.00	0.001	0.001
M3	0.69	0.76	0.65	0.529	0.692	0.002	0.00	0.00	0.00	0.001	0.001
M4	0.67	0.76	0.65	0.529	0.692	0.003	0.00	0.00	0.00	0.002	0.002
M5	0.57	0.78	0.71	0.529	0.692	0.008	0.00	0.00	0.00	0.004	0.006
M6	0.57	0.76	0.73	0.529	0.692	0.007	0.00	0.00	0.00	0.004	0.005
M7	0.73	0.78	0.65	0.529	0.692	0.001	0.00	0.00	0.00	0.001	0.001
M8	0.33	1.00	1.00	0.600	1.000	0.139	0.04	0.13	0.13	0.083	0.139
M9	0.81	0.88	0.57	0.529	0.692	0.006	0.00	0.00	0.00	0.003	0.004
M10	0.45	0.55	0.71	0.529	0.692	0.042	0.01	0.02	0.03	0.022	0.029
M11	0.36	0.45	0.61	0.529	0.692	0.125	0.04	0.05	0.07	0.066	0.087
M12	0.36	0.39	0.42	0.529	0.692	0.203	0.07	0.08	0.08	0.107	0.141
M13	0.37	0.45	0.42	0.529	0.692	0.154	0.05	0.07	0.06	0.082	0.107
M14	0.40	0.50	0.43	0.529	0.692	0.112	0.04	0.05	0.04	0.059	0.078
M15	0.44	0.61	0.45	0.529	0.692	0.071	0.03	0.04	0.03	0.038	0.049
M16	0.55	0.76	0.61	0.529	0.692	0.013	0.00	0.01	0.00	0.007	0.009
M17	0.61	0.78	0.67	0.529	0.692	0.005	0.00	0.00	0.00	0.003	0.003
M18	0.42	0.81	0.65	0.529	0.692	0.044	0.01	0.03	0.02	0.023	0.030
M19	0.58	0.78	0.76	0.529	0.692	0.005	0.00	0.00	0.00	0.003	0.003
M20	0.73	0.71	0.67	0.529	0.692	0.001	0.00	0.00	0.00	0.001	0.001
M21	0.58	0.76	0.71	0.529	0.692	0.006	0.00	0.00	0.00	0.003	0.004
M22	0.55	0.81	0.71	0.529	0.692	0.009	0.00	0.00	0.00	0.005	0.006
M23	0.50	1.00	0.61	0.529	0.692	0.022	0.01	0.02	0.01	0.012	0.015
M24	0.51	0.81	0.61	0.529	0.692	0.019	0.01	0.01	0.01	0.010	0.013
total							0.401	0.598	0.578	0.539	0.735

Table 5 Classification of teachers’ performance appraisal

Excellent range	Qualified range	Unqualified range
(0.735,1]	(0.539,0.735]	(0,0.539]

Third, none of the three of them achieved excellent performance. Observing the original data, we can see that :The scores of the seven indicators of I10, I11, I12, I13, I14, I15, and I18 were too low, and the average score of the five experts did not exceed 7 points. And 5 of these 7 indicators are subordinate to the second-level indicator "scientific research". This also seems to reflect the fact that vocational colleges generally do not pay attention to the scientific research work of teachers. On the other hand, compared with other second-level indicators, experts give discrete scores to the five third-level indicators under the second-level indicator of "scientific research" .According to the principle of entropy method, this leads to the extremely heavy weight of the second-level indicators. This is also the reason why the overall assessment score of the three is not high.

4. Conclusion

Based on the characteristics of higher vocational colleges, This article establishes a higher vocational college teacher’s performance appraisal system from four dimensions of talent training, scientific research, social services, and teacher development, which is more systematic and comprehensive determine the assessment standards of teachers. Based on the above evaluation system, an evaluation model based on entropy weight and grey relational degree is developed, which eliminates the influence of small sample and subjectivity on the system, reduces the difficulty of manipulation, and provides a new idea for teachers’ performance appraisal.

5. Suggestions

As an important means of standardized management in higher vocational colleges, the fundamental purpose of teachers’ performance appraisal is to mobilize the enthusiasm of teachers and improve the comprehensive quality of teachers, so as to optimize the efficiency of higher vocational colleges. Based on this, this paper puts forward the following suggestions for the performance appraisal system and evaluation methods.

5.1 Attach great importance to performance appraisal

Teachers' performance appraisal is the basis of personnel management in higher vocational colleges, such as the selection, appointment, salary, reward and punishment of teachers, and plays an important role in the school management system. The college should attach great importance to teachers' performance appraisal. It is necessary to set up a special leading group for performance appraisal to ensure the fairness, impartiality and openness of the appraisal work; establish a long-term tracking database system for teachers' appraisal; update teachers' performance appraisal materials constantly; review teachers' appraisal materials strictly. In addition, in the formulation of incentive policies for teachers based on performance appraisal, it is suggested to increase the intensity of rewards and punishments, so as to fundamentally improve the enthusiasm of teachers.

5.2 Establish a dynamic evaluation index system

Higher vocational college is different from the general undergraduate colleges, which focuses on the cultivation of students' skills. With the social progress, economic development and the change of domestic and foreign environment, the demand for the type and quantity of skills of enterprises is constantly changing. The personnel training program, teaching objectives, including teachers' performance appraisal system, etc. of higher vocational colleges should adapt to this change. Therefore, we should implement the party's and state's guidelines and policies on the cultivation of skilled talents thoroughly; understand the demand information of talents in the society timely ; revise and improve the evaluation index system of teachers' performance appraisal Constantly ; so that teachers' performance appraisal can become an effective way to improve the school running efficiency.

5.3 Select appropriate evaluation method

At present, there are many ways to evaluate teachers' performance. On the whole, qualitative

analysis is too subjective, cumbersome operation procedures, relatively high cost and generally controversial. Quantitative analysis is complex and difficult to understand, and quantitative analysis is often limited by the number of samples, so the weight and evaluation level calculated by low sample size is difficult to be convincing. Therefore, in the selection of evaluation system, we should combine with the actual situation of our school, and find the most suitable method in many qualitative and quantitative analysis. At the same time, qualitative analysis and quantitative analysis can be combined to avoid the shortcomings of the two and make a comprehensive evaluation.

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