Study of Teachers' Evaluation on Students in Colleges and Universities Based on the Subjective, Objective and Combined Weighting - Cloud Evaluation Model

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Abstract. The establishment and application of a scientific and effective model and method play a pivotal role in conducting high-quality work of teachers' evaluation on students in colleges and universities. With regard to the problem of setting the weights of the evaluation indexes of teachers in colleges and universities, this study applied the critic method to assign objective weights and linearly combined with the subjective weighting results to derive the weight values combining subjective and objective; in view of the problem of comprehensive research and judgment of the evaluation results, the cloud evaluation model was used to present and analyze the overall performance and the performance of primary indicators, which achieved a more satisfactory effect overall. Thus, this study carried out an innovative exploration for improving the quality and effectiveness of the work of teachers' evaluation on students in colleges and universities.

Keywords: Combined Weighting · Cloud Evaluation · Teachers' Evaluation on Students

1 Introduction

According to the *Overall Plan for Deepening the Reform of Educational Evaluation in the New Era* issued by the Central Committee of the Communist Party of China and the State Council [7], "reforming student evaluation" has become one of the "key tasks", and an important aspect of student evaluation is that teachers evaluate the classes they teach, i.e., "teachers' evaluation on students". For higher education institutions, which are founded on moral education, they should deeply understand the important proposition and practical logic given to teachers' evaluation on students in the new era, scientifically and effectively carry out activities of teachers' evaluation on students, continuously strengthen and improve the work of teaching units and student management units, and solidly promote the continuous improvement of talent training quality.

The establishment and application of scientific and effective models and methods are the keys to high-quality activities of teachers' evaluation on students. However, many useful studies and explorations have been conducted in recent years on the optimization

C. F. Peng et al. (Eds.): EIMT 2022, AHSSEH 3, pp. 76–87, 2023.
https://doi.org/10.2991/978-94-6463-012-1_10

of weights, the use of models and instruments, the analysis of results, and other model methods concerning teachers' evaluation on students in academic circles. In terms of weight optimization, Yang Han (2021), Ning Yihan (2015), et al. focused on setting and tuning the weight of indicators for teachers' evaluation on students by using the analytical hierarchy process (AHP) [6, 11]; Wang Jing (2018) et al. emphasized on setting the weights of primary and secondary indicators of teachers' evaluation on students using superior order diagram method and direct weighting method, respectively [8]. With respect to the application of models and means, Chi Ziying (2016) et al. highlighted the construction of a two-level fuzzy comprehensive evaluation model for teachers' evaluation on students and demonstrated it with application examples [2]; Wei Peiyan (2021) et al. discussed the efficient use of information technology tools such as the educational administration system [9]; Han Lizhu (2017) et al. placed emphasis on the introduction of the "learning engagement survey" questionnaire into the process of teachers' evaluation on students, which enriched and expanded the connotation of the evaluation [4]. Regarding result analysis, Hou Jiancheng (2019) and Ge Fei (2018) conducted a statistical analysis of the evaluation results and analyzed the problems [3, 5]; Zhong Ting (2020) also used data mining methods such as clustering and correlation to analyze students' related performance [12]; Cai Jinghan (2014) centered on the reliability and validity tests of the scale of teachers' evaluation on students and revised and improved the content of the scale [1]; Yang Hirong (2016) stressed on the correlation between sub-scores and total scores of teachers' evaluation on students [10].

In a nutshell, there are still two shortcomings in the current related research that cannot be ignored and need to be discussed in depth: First, concerning the setting and adjustment of weights, the methods currently used still rely on subjective weighting, which is more artificial and subjective, and is more restricted by the ability level of experts; second, there is a lack of attention and consideration to the random distribution of teachers' evaluation results, which to a certain extent affects the comprehensiveness and accuracy of the evaluation results. To this end, this study explores the use of the critic method for objective weighting, and combines it with subjective weighting to form a combination of weights, so as to enhance the scientific and credible setting of weights; in the meantime, the cloud evaluation model is used to study and analyze the evaluation results, pay attention to and consider their randomness, and present and display them in the form of cloud charts, thereby reflecting the results of teachers' evaluation in a more comprehensive and realistic way.

2 Study Design

2.1 Research Subjects

This study focuses on the setting of weights for the evaluation indicators of teachers' evaluation on students in H University, as well as the establishment and application of the analysis model of the evaluation results. The basis and starting point of this study is the two-level indicator framework of teachers' evaluation on students established by the previous literature research and experts' demonstration (see Table 1, which contains five primary indicators of "learning attitude", "earning ability", "learning method", "learning

Table 1. Indicator framework of teachers' evaluation on students in H university

Primary indicators	Secondary indicators
A learning attitude	Students have a clear learning purpose and know why they are learning
	Students have a clear motivation to learn
	Students are drowsy and deserting in class
	The classroom learning atmosphere is enthusiastic, and students are highly motivated, listen carefully, and have a quick understanding and response-ability
	Students follow the flow of lectures and take notes carefully
	Students preview, review, and summarize carefully after class
	Students complete their homework in a timely and serious manner without plagiarism
B learning ability	Students have a solid foundation in prerequisite courses
	Students have strong learning ability and can use the extra time for self-study after class
	Students are good at thinking, with a large number of questions and high-quality questions
	Students are good at asking new questions and expressing new ideas
	Students have strong hands-on ability
C learning methods	Students are able to adapt and master the learning methods of the course
	Students have flexible thinking and a strong ability to inference
	Students are adept at learning with modern information technology tools
D learning effect	The achievement rate of students' course objectives or the mastery rate of classroom knowledge is above 80%
	The achievement rate of students' knowledge, ability, and skills after the end of class is 80% or more
	Students' overall learning tasks are completed promptly, with high quality and good effect
	Students have satisfactory scores on their regular tests and final assessments

(*continued*)

Table 1. (*continued*)

Primary indicators	Secondary indicators
E learning style and discipline	Students have a firm idea of serving the people wholeheartedly, and adhere to and support the party's line, principles, and policies
	Students have the lofty ideal of "learning for the modernization of national defense construction and win", and volunteer to devote themselves to the cause of national defense
	Students love their majors
	Students are energetic, positive, and dynamic
	Students have a high attendance rate and unexcused absenteeism
	Students have good exam style
	Students strictly implement teaching rules and regulations, and there is no violation of discipline

effect" and "learning style and discipline" and 26 secondary indicators, and no weights have been established yet).

With regard to the data set, the trial evaluation results of 26 secondary indicators of 35 representative classes were selected as the data set for the objective weighting of critic; the evaluation results of 11 experts on the importance of 5 primary indicators and 26 secondary indicators were used as the data set for the subjective weighting; a class was selected as an example for analysis, and the evaluation results of 21 teachers who had taught the class were used as the data set for the cloud model analysis.

2.2 Analytical Methods

2.2.1 Critic Method

The critic method is a classic weighting method. The critic method synthesizes the information of both variability and correlation contained in the sample data of each indicator evaluation, and the objective weighting can take into account the two important factors of indicator variability and confliction compared with the entropy weighting method and standard deviation method. The values of the objective weights assigned by the critic method are proportional to the variability of the evaluation sample data and inversely proportional to the correlation, thus strengthening the differentiation of the evaluation indicators.

a) Evaluation of Data Matrix

For m groups of samples and n indicators, the judgment matrix is:

$$\mathrm{X} = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \mathrm{m} \times \mathrm{n} \tag{1}$$

In the formula, xij (i = 1, 2, 3,… m, j = 1, 2, 3, … n) is the original data taken for the i-th evaluation object under the j-th indicator.

b) Evaluation of data processing

In order to eliminate the influence of different dimensions on the evaluation results, each indicator is usually dimensionless.

$$\mathrm{x}'_{\mathrm{ij}} = \frac{\mathrm{x_j} - \mathrm{x_{min}}}{\mathrm{x_{max}} - \mathrm{x_{min}}} \tag{2}$$

c) Indicator variability

The indicator variability is reflected by the standard deviation, and its quantitative indicator is the standard deviation Sj.

$$\begin{aligned} \overline{\mathrm{x_j}} &= \frac{1}{\mathrm{m}} \sum\nolimits_{i=1}^{\mathrm{m}} x_{ij} \\ S_j &= \sqrt{\frac{\sum_{i=1}^{\mathrm{m}} \left(x_{ij} - \overline{x_j}\right)^2}{\mathrm{m} - 1}} \end{aligned} \tag{3}$$

Sj is the standard deviation of the j-th indicator.

d) Indicator confliction

The quantitative indicator Rj of indicator confliction takes the correlation coefficient as the decisive variable.

$$R_{\mathrm{j}} = \sum\nolimits_{i=1}^{\mathrm{n}} (1 - r_{ij}) \tag{4}$$

$\mathrm{r_{ij}}$ is the correlation coefficient between indicator i and j.

e) Indicator information quantity

The quantitative indicator Cj of the indicator information quantity is obtained by multiplying Sj and Rj.

$$C_{\mathrm{j}} = S_{\mathrm{j}} \sum\nolimits_{i=1}^{\mathrm{n}} (1 - r_{ij}) = S_j \times R_{\mathrm{j}} \tag{5}$$

f) objective weight value

The objective weight derived by the critic method is characterized by Wj.

$$W_{\mathrm{j}} = \frac{C_{\mathrm{j}}}{\sum_{\mathrm{j}=1}^{\mathrm{n}} C_{\mathrm{j}}} \tag{6}$$

2.2.2 Cloud Evaluation Method

The cloud evaluation method is a relatively mature evaluation model and analysis method. The method takes full account of the random distribution characteristics of a set of evaluation results given by different evaluators, refines the characteristic variables such as expectation and variance of the set of evaluation results, and uses them as the control parameters of the cloud pattern in the cloud map. To this end, the set of evaluation results can be studied and judged holistically at a glance through the presentation of the cloud pattern. The cloud evaluation method can avoid the imperfection of the traditional statistical average method and other results analysis methods. In addition, according to theories such as the law of large numbers and combined with practical experience, normally distributed cloud layers are usually generated in the application of cloud evaluation models.

a) Expectation

The expectation of the source data of the cloud model is expressed as Ex, which determines the central position of the cloud layer.

$$E_{\mathrm{x}} = \frac{1}{n}\sum_{i=1}^{n} x_i \tag{7}$$

x_i is the i-th value of a group of evaluation samples, and n is the number of samples.

b) Entropy

The entropy of the cloud model source data is represented by En, which determines the width of the cloud layer.

$$E_{\mathrm{n}} = \sqrt{\frac{\pi}{2}} \times \frac{1}{\mathrm{n}}\sum_{i=1}^{\mathrm{n}} |x_i - E_x| \tag{8}$$

c) Hyperentropy

The hyperentropy of the cloud model source data, denoted by He, determines the thickness of the cloud layer.

$$H_{\mathrm{e}} = \sqrt{S^2 - E_n^2} \tag{9}$$

$$S^2 = \frac{1}{\mathrm{n}-1}\sum_{\mathrm{i}=1}^{\mathrm{n}} (\mathrm{x_i} - E_x)^2 \tag{10}$$

S2 is the sample variance.

d) Cloud image generation algorithm

Input: sample features (Ex, En, He), the number of cloud droplets to be generated n
Output: cloud droplet distribution drop (xi, μi), i = 1, 2, …, n

Step 1, a normal random number Eni' with Ex as the expectation and He2 as the variance is generated
Step 2, a normal random number xi with Ex as the expectation and Eni2 as the variance is generated
Calculation

$$\mu_i = e^{\frac{(x_i - Ex)^2}{2(En_i')^2}} \tag{11}$$

It is needed to repeat Step 1 until n cloud droplets that meet the requirements are generated.

2.3 Research Steps

First, objective weighting is carried out. 35 representative classes of H University in the fall semester of 2021 were selected, and trial evaluation was implemented according to the secondary indicator framework for teachers' evaluation on students established earlier to obtain 35 groups of evaluation samples of 26 secondary indicators. Then the critic method was used to obtain objective weights of 26 secondary indicators.

Subsequently, subjective weighting is performed. 11 experts in the field of teacher evaluation were invited to rate the importance of 5 primary indicators and 26 secondary indicators according to 7 grades. With statistical frequency as the degree of membership, the initial values of subjective weights of 5 primary indicators and 26 secondary indicators were derived separately. On this basis, the subjective weights of the primary indicators were multiplied by the initial values of the subjective weights of the secondary indicators, and the final values of the subjective weights of the secondary indicators were obtained.

Next, the subjective and objective weighting results of the 26 secondary indicators were synthesized. This study adopted a linear combination method (the proportion of subjective weighting and objective weighting can be set in combination with work needs and expert advice, and this research used a ratio of 4:6) to obtain the final combined weighting value.

It should be noted that in each step of the weight-related operation, each group of weights was uniformly converted into a proportional form (the sum is 1) to ensure consistency and comparability in the calculation and processing process.

Finally, the cloud evaluation model was employed to carry out case analysis. The class F of H University was selected as the case analysis object, and 21 teachers who have taught for the class in the fall semester of 2021 were invited to conduct practical evaluations. The evaluation results of each teacher were comprehensively analyzed by means of the cloud evaluation model.

3 Results

3.1 Weighting Results

The results of objective weighting, subjective weighting, and linear combined weighting are shown in Table 2.

Table 2. Table of indicator weights of teachers' evaluation on students in H University

Indicator	Weights		
	Objective weight	Subjective weight	Combined weight
A	–	0.1931	0.2255
A1	0.0112	0.0262	0.0777
A2	0.0158	0.0279	0.0206
A3	0.0185	0.0254	0.0213
A4	0.0214	0.0279	0.0240
A5	0.0249	0.0283	0.0263
A6	0.0262	0.0279	0.0267
A7	0.0285	0.0296	0.0289
B	–	0.2056	0.1871
B1	0.0297	0.0415	0.0344
B2	0.0327	0.0409	0.0360
B3	0.0359	0.0403	0.0377
B4	0.0384	0.0396	0.0389
B5	0.0380	0.0433	0.0401
C	–	0.1869	0.1474
C1	0.0415	0.0646	0.0507
C2	0.0387	0.0626	0.0483
C3	0.0408	0.0597	0.0484
D	–	0.2056	0.1940
D1	0.0427	0.0501	0.0457
D2	0.0432	0.0501	0.0460
D3	0.0507	0.0523	0.0513
D4	0.0496	0.0531	0.0510
E	–	0.2087	0.3065
E1	0.0485	0.0296	0.0409
E2	0.0535	0.0314	0.0447
E3	0.0512	0.0296	0.0426
E4	0.0527	0.0305	0.0438
E5	0.0538	0.0291	0.0439
E6	0.0565	0.0282	0.0452
E7	0.0554	0.0305	0.0454

Table 3. Corresponding relationship between teacher's evaluation results and grades in H University

Score	(100,80]	(80,60]	(60,40]	(40,20]	<20
Grade	A	B	C	D	E

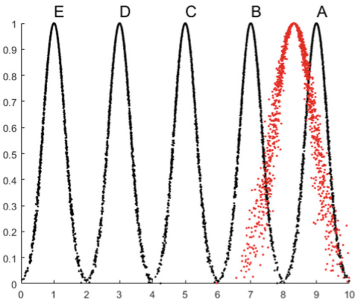

Fig. 1. The cloud map of the total grades of teachers' evaluation on students in class F

3.2 Grading of the Evaluation Results

The evaluation results are graded in five grades, with points of 100, 80, 60, 40, 20, and 0, corresponding to five grades from A to E. The corresponding relationship between the scores and grades is shown in Table 3.

3.3 Results of the Cloud Evaluation

The analysis results of the cloud evaluation model for the total grades of the teachers' evaluation on students in class F and the grades of 5 primary indicators are presented in Figs. 1 and 2, respectively. Among them, the black cloud layer is the preset "standard cloud" of the relevant grade, and the red cloud layer is the "result cloud" obtained from the actual evaluation.

As shown in Fig. 1, the total grades of the teachers' evaluation on students in class F are ranged between "A" and "B" from the center of the cloud, which is biased toward "A", reflecting the excellent academic style of the students in the class as a whole; from the distribution of the cloud drops, the cloud has a certain width and thickness, reflecting the dispersion of the results of the teachers' evaluation on students in the group; after the overall study and judgment, the total grades can be judged as "A". By analogy, it can be seen from Fig. 2 that the grades of the primary indicators of "learning attitude", "learning ability", "learning method", "learning effect" and "learning style and discipline" can be judged as "A, B, B, A, A", respectively. Judging from the performance of the primary indicators, this class performed well in terms of "learning attitude", "learning effect", and "learning style and discipline", which played a role in boosting the total score and should be carried forward and maintained; however, it is insufficient in "learning ability" and "learning method", which has "dragged down" the overall performance and needs to be made up and improved pertinently in the subsequent teaching and management.

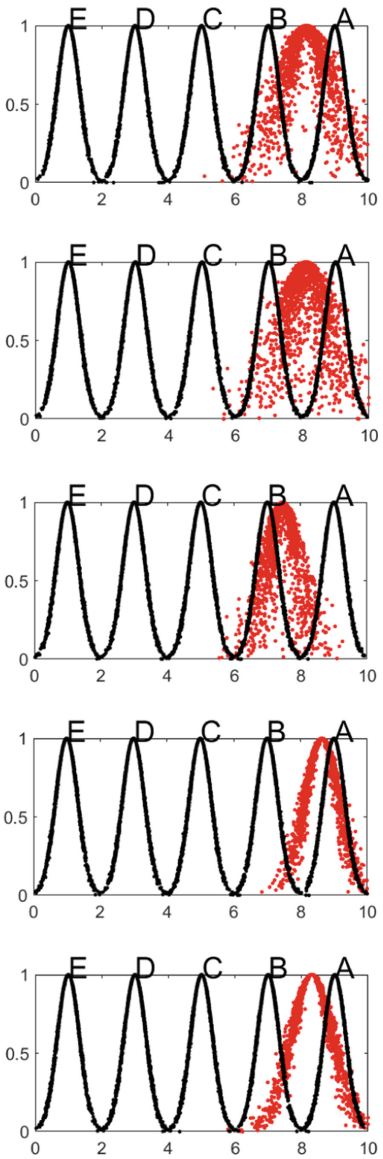

Fig. 2. The cloud map of grades of five primary indicators of teachers' evaluation on students in class F

4 Conclusions

With a view to addressing the problem of setting the weights of the evaluation indicators of teachers' evaluation on students in colleges and universities teachers, this study uses the critic method for objective weighting and linear combination with the subjective weighting results to derive the combined subjective and objective weight values; for the

comprehensive study and judgment of the evaluation results, the cloud evaluation model is used to present and analyze the overall performance and the performance of primary indicators, resulting in a more satisfactory result overall. After further summarizing and thinking, the following conclusions can be drawn:

a) The objective weighting method has broad application space and extraordinary significance in the field of teachers' evaluation on students
   Teachers' evaluation on students in colleges and universities is an activity with wide coverage, a large sample size, and a strong correlation. Admittedly, in principle, all classes should be evaluated, all teachers should implement the evaluation, and all students as individuals in the class will be covered as a whole; at the same time, the correspondence between teachers and classes is clearly related and highly determined. The objective weighting method just depends on the data set with strong representativeness and sufficient quantity. It can be said that it is very suitable for the field of teachers' evaluation on students. Related research is still relatively lacking, and there is still a broad space for exploration. Objective weighting in teachers' evaluation activities is not only applicable to the establishment stage of indicator weights, where dozens of classes are organized to carry out trial evaluations and establish a weighting system based on objective weighting according to the trial evaluation results; it is also applicable to the adjustment stage of existing indicators, where dozens or even hundreds of evaluation results are selected on a representative basis, and the weights of existing indicators are revised and optimized with objective weighting values, which are of great significance to continuously enhance the scientificity and credibility of weight settings.
b) The cloud evaluation model has obvious application effects and outstanding advantages in the field of teachers' evaluation on students
   The form of teachers' evaluation results in a class is a set of evaluation data given by different teachers who have taught the class. In the process of the comprehensive analysis of teachers' evaluation results, it is common to combine these data into one by averaging them, which inevitably leads to loss of information and distortion, and even to the suspicion of being "definitive" and "conclusive". With the cloud evaluation model, by refining the parameters of expectation, entropy, and hyperentropy, cloud maps of different shapes are generated, which can fully retain and reflect the information contained in the whole set of evaluation results, be visually and vividly presented, and leave room for the data analysts to judge with "different opinions". It can be said that the cloud evaluation model not only provides a scientific and effective means of support for teachers' evaluation activities but also brings a new concept and new idea to the analysis of teachers' evaluation results, which will effectively promote the development of teachers' evaluation progress and development.

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