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PAPER

Online Teaching Effect Evaluation and Analysis Using Combined Weighting Technique

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ABSTRACT

An evaluation index system of online teaching satisfaction was established based on the data of a questionnaire survey. In addition, an evaluation index system of an online teaching effect with four first-level indexes and 14 second-level indexes was constructed from the aspects of pre-class preparation, video production, classroom teaching, and after-class guidance. Then, a combination weighting–Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) model was established using the analytic hierarchy process (AHP), Criteria Importance Through Inter-criteria Correlation method, and TOPSIS model. The objective is to evaluate the online teaching effect of 10 engineering technology universities in Henan Province. Results show that the online teaching effect of these universities is generally satisfactory. In addition, video production and classroom teaching are important factors affecting online teaching, which, however, is slightly influenced by pre-class preparation. On this basis, this study proposes to enhance online assessment, improve students' attention in class, strengthen teacher–student communication, actively perfect teaching resources, and create a good learning environment.

KEYWORDS

online teaching, analytic hierarchy process, CRITIC method, TOPSIS model, influencing factors

1 INTRODUCTION

In the era of the mobile Internet, the mobile terminal equipment rate of college teachers and students is very high, and the general trend is to realize online learning by using mobile intelligent terminals. In the 21st century, China's higher education has entered the stage of mass education, with quality problems emerging one after another. Improving the quality of higher education is the eternal theme of China's education development. The "teacher-centered" evaluation system is universal. Hence, students' subjective status is not directly faced, making it impossible to evaluate teachers' teaching quality in teaching activities from the students' perspective. Meanwhile, many colleges and universities in China have not yet established a

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scientific and reasonable evaluation system for teachers' teaching quality. In addition, some are subjected to various problems in the implementation of the evaluation system, for example, the ineffective implementation of evaluation instructions, the formalized evaluation process, and the considerable deviation of evaluation results from the facts. In many cases, teachers' teaching quality is evaluated formally, failing to play an effective role in monitoring the teaching quality. Establishing and perfecting the evaluation system of teaching quality in colleges and universities are an important measure to improve the teaching quality. In addition, the objective evaluation of teaching quality by each evaluation subject is the basic premise for improving the quality evaluation system. The research on the evaluation system of teachers' teaching quality in colleges and universities can help colleges and universities keep up with the development trend of the times, improve teaching methods, improve teachers' teaching quality, and accomplish the important task of talent cultivation.

Talent cultivation is the basic goal of education, and different teaching methods are important factors affecting the quality of education, which is measured based on an important standard, namely, the evaluation of student satisfaction. With the development of science and technology, online teaching has become increasingly popular. Software such as *Xuexitong* and *DingTalk* can realize online teaching and share educational resources. Colleges and universities have paid increasing attention to online teaching and taken a series of measures to standardize teaching, thereby improving teaching quality. Teaching satisfaction refers to students' evaluation and satisfaction with the teaching model, teaching content, teaching process, and teaching quality in a large range. Many factors affect teaching satisfaction, among which teachers are the most important. Teachers who are knowledgeable, care about students, and attach importance to teaching quality will naturally win students' satisfaction. Students themselves are also an important determinant. Students keeping focused can gain additional knowledge from teaching. In addition, the environment is a particularly important factor. A smooth network and a quiet environment are all important factors affecting satisfaction. Since the COVID-19 outbreak, large-scale, real-time, interactive, remote, and decentralized online teaching have changed the basic form of higher education in China. This event tests the teaching and learning of teachers and students and challenges the traditional teaching evaluation system based on the online classroom teaching model. Therefore, constructing a three-dimensional teaching effect evaluation system has a promoting effect on measuring the teaching effect of college teachers and improving the learning efficiency and teaching level. This case also has certain practical significance for the teaching reform of higher education. Furthermore, establishing a scientific and standardized teaching evaluation system is a new topic for higher education management in China.

2 LITERATURE REVIEW

At present, Chinese and foreign scholars have systematically studied the evaluation of university teaching. Foreign scholars have empirically investigated the effectiveness of teaching evaluation mainly through quantitative research methods. For instance, K Plante et al. [1] measured the effectiveness of teaching evaluation as an index of teachers' teaching effect by analyzing the relationship between teaching evaluation results and students' academic achievements based on neural network analysis. J C Richardson et al. [2] discussed the problems in the teaching evaluation system of research universities and the reform path from the perspective of first-class undergraduate education. J M Price [3] built a teaching evaluation index system through quantitative research. R H Ellaway et al. [4] established an inquiry-based classroom teaching evaluation index system of "teachers' classroom teaching, students' classroom performance, and inquiry effect detection" through a questionnaire survey on relevant experts, teachers, and supervisors. A questionnaire investigating the influence of online instructional interaction level on sustained learning results was designed. By considering self-efficacy as a mediating variable, the mediating effect of self-efficacy on sustained learning results at the interactive level of online teaching was analyzed and the difference in sustained learning results that can be attributed to years of familiarity with online learning was measured [5]. The relevant conclusions of the above research point out the basic follow-up research direction. In the new high-quality development period of higher education, however, the basic characteristics, important problems to be solved urgently, and reform paths of the online teaching evaluation system in universities have not been systematically combed and explained. The evaluation of teaching quality is conducive to the effective supervision and management of teaching quality by the teaching management department, the timely discovery of problems by teachers, the improvement of teaching, and ultimately, the overall improvement of teaching quality. Therefore, scientific and efficient teaching quality evaluation methods have become a research hotspot, and many scholars have established mathematical evaluation models, such as the fuzzy comprehensive evaluation method [6], analytic hierarchy process (AHP) [7], and grey relational analysis method [8]. With the development and popularization of artificial intelligence technology, neural networks have overcome the limitations of the above methods through their characteristics, such as nonlinear processing, adaptive learning, and high fault tolerance [9]. Many scholars [10]. The concept of teaching satisfaction is an extension of the concept of customer satisfaction, and online teaching satisfaction is an important aspect to evaluate the quality of online teaching. Some scholars have conducted considerable research on teaching satisfaction. Based on Herzberg's two-factor theory, Z Chen [11] constructed a satisfaction evaluation index system from four aspects: teaching course, teacher–student interaction, counselor support, and community activities. Li M et al. [12] designed an evaluation method for online teaching quality of basic education in the context of the Artificial Intelligence (AI). The application of the AI in basic education was analyzed, and the promoting effect of online teaching on basic education was confirmed. On this basis, the entropy weight method and grey clustering analysis were introduced to evaluate the online teaching quality of basic education. A Darabi et al. [13] established a satisfaction evaluation index system from six dimensions: self-development, cultural and sports life, logistics support, teaching staff, teaching situation, and teaching conditions. J Huizhen [14] evaluated students' satisfaction using 45 indexes from four dimensions, namely, knowledge construction, teacher–student interaction, information processing, and learning effectiveness. R H Ellaway et al. [15] thought that learners' online learning behaviors, learning process, and teacher's instruction have great influences on satisfaction. X Meng et al. [16] proved through regression analysis that students' satisfaction is affected by practical teaching, professional courses, teachers, and teaching facilities. B Mastel-Smith et al. [17] believed that satisfaction is not only directly related to the perception of practical teaching quality but also indirectly related to the medium, namely, perceived value. B Rubin et al. [18] studied and analyzed the influence of teachers' role, curriculum design, teacher–student interaction, student–student interaction, and learning motivation on online effective learning by constructing structural equations. Y Wen et al. [19] concluded through factor analysis that the teacher–student interaction in the teaching process, the preparation of teachers' teaching content, the learning time of students, and the participation of students have different influences on online teaching satisfaction. L M Carter et al. [20] thought that the influences of teaching methods, teaching effect and innovation ability, teaching content, and teaching attitude on teaching satisfaction decrease successively. H Wang et al. [21] found that the communication intensity between teachers and students has a strong influence on effective online learning. S Zhang [22] pointed out that the image of colleges and universities has a positive influence on students' expectations, quality perception, and satisfaction. T B Crews [23] deemed that students' quality perception has a great influence on students' satisfaction.

To sum up, scholars have extensively investigated the evaluation of teaching satisfaction and its influencing factors and achieved certain results. However, network teaching and teaching satisfaction have been rarely explored as they mostly focused on qualitative analysis. Based on a questionnaire survey, an evaluation index system for network teaching satisfaction was established in this study to comprehensively analyze network teaching satisfaction. Then, the factors influencing satisfaction were analyzed from three aspects: teaching quality, student subject, and teaching environment, providing a reference for solving network teaching problems and improving teaching quality. As China's higher education has entered a high-quality development stage, this study found the core meanings of the high-quality development of higher education and proposed new requirements for the college teaching evaluation system. Next, this study deeply analyzed the conflict between the current college teaching evaluation system and high-quality development in China to discuss the future reform paths and provide suggestions.

3 METHODOLOGY

This study evaluated the online teaching effect using the AHP–Criteria Importance Through Inter-criteria Correlation (CRITIC) combination weighting and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method. Before TOPSIS-based evaluation, the weight of each index was calculated through AHP–CRITIC combination weighting.

3.1 TOPSIS method

The TOPSIS method can eliminate the dimensional influence on different indexes through normalization and common trend processing of initial data and objectively reflect the real gap among schemes. First, m objectives (limited objectives) and n attributes are set, and the evaluation value given by experts to the attribute j of the objective i is x_{ij}. Then, the initial judgment matrix V is as follows:

$$V = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{1}$$

Given that the dimension may vary from index to index, the judgment matrix V' is acquired by normalizing the initial judgment matrix V, thereby obtaining Eq. (2).

$$V' = \begin{bmatrix} x'_{11} & x'_{12} & \cdots & x'_{1n} \\ x'_{21} & x'_{22} & \cdots & x'_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x'_{i1} & \cdots & x'_{ij} & \cdots \\ \vdots & \vdots & \vdots & \vdots \\ x'_{m1} & x'_{m2} & \cdots & x'_{mn} \end{bmatrix} \tag{2}$$

$$x'_{ij} = {x_{ij}} \Big/ {\sqrt{\sum_{k=1}^{n} x_{ij}^2}}, i = 1,2,\ldots m; j = 1,2,\ldots n \tag{3}$$

Then, the information weight matrix B of the expert group for attributes is acquired through AHP, and the weighted judgment matrix Z is formed, as in Eq. (4).

$$Z = V'B = \begin{bmatrix} x'_{11} & x'_{12} & \cdots & x'_{1n} \\ x'_{21} & x'_{22} & \cdots & x'_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x'_{i1} & \cdots & x'_{ij} & \cdots \\ \vdots & \vdots & \vdots & \vdots \\ x'_{m1} & x'_{m2} & \cdots & x'_{mn} \end{bmatrix} \begin{bmatrix} w_{11} & w_{12} & \cdots & w_{1n} \\ w_{21} & w_{22} & \cdots & w_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ w_{i1} & \cdots & w_{ij} & \cdots \\ \vdots & \vdots & \vdots & \vdots \\ w_{m1} & w_{m2} & \cdots & w_{mn} \end{bmatrix} = \begin{bmatrix} f_{11} & f_{12} & \cdots & f_{1n} \\ f_{21} & f_{22} & \cdots & f_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ f_{i1} & \cdots & f_{ij} & \cdots \\ \vdots & \vdots & \vdots & \vdots \\ f_{m1} & f_{m2} & \cdots & f_{mn} \end{bmatrix} \tag{4}$$

Based on the weighted judgment matrix, the positive ideal solution f_j^* and negative ideal solution f_j' of the evaluation objectives are acquired as shown in Eq. (5).

$$\begin{aligned} f_j^* &= \begin{cases} \max(f_{ij}), j \in J^* \\ \min(f_{ij}), j \in J' \end{cases}, j = 1,2,\ldots,n \\ f_j' &= \begin{cases} \min(f_{ij}), j \in J^* \\ \max(f_{ij}), j \in J' \end{cases}, j = 1,2,\ldots,n \end{aligned} \tag{5}$$

Where J' is a cost index and J^* is a benefit index. The Euclidean distance between each objective value and the ideal value is solved as per Eq. (6).

$$\begin{aligned} S_i^* &= \sqrt{\sum_{j=1}^{m} (f_{ij} - f_j^*)^2}, j = 1,2,\ldots,n \\ S_i' &= \sqrt{\sum_{j=1}^{m} (f_{ij} - f_j')^2}, j = 1,2,\ldots,n \end{aligned} \tag{6}$$

Finally, the relative closeness of each objective is calculated as shown in Eq. (7).

$$C_i^* = \frac{S_i'}{S_i^* + S_i'}, i = 1,2,\ldots,m \tag{7}$$

According to the relative closeness C_i^*, the objectives are sorted to form a decision basis.

3.2 Improvement of the TOPSIS method based on combination weighting

At present, most scholars have ranked control variables using the Delphi method or questionnaire survey method. However, the ranking results are usually quite subjective and cannot be changed according to the relative change degree of each control variable, leading to the lack of objectivity and reasonability of evaluation results. In this study, the importance of evaluation indexes was ranked through the AHP–CRITIC combination weighting method, ensuring the objectiveness and reasonability of the online teaching effect evaluation index system.

Objective weight calculation based on AHP. In the hierarchical structure model, the bottom layer is generally the factor layer, and all kinds of basic risk factors identified serve as the second-level indexes of risk evaluation. The middle layer is the criterion layer, which classifies risk factors as the first-level indexes of risk evaluation. The top layer is the objective layer, that is, the decision-making objectives that risk quantification needs to achieve. After the evaluation objectives, plans, standards, and indexes are determined, the hierarchical model of the system can be constructed to comprehensively identify and analyze the risk factors. Then, a judgment matrix is established. Based on the established risk hierarchical structure, the quantitative scale among factors is made using the nine-point scale method according to the comparison between every two factors and their importance.

The product of the matrix elements a_{ij} is calculated by row to obtain a new vector M_i, as shown in Eq. (8).

$$M_i = \prod_{j=1}^{n} a_{ij} (i, j = 1,2,3,\ldots,n) \tag{8}$$

The n-th root of each element in the new vector M_i is taken to obtain the vector r_i, as shown in Eq. (9).

$$r_i = \sqrt[n]{M_i} \tag{9}$$

Then, r_i is normalized to obtain the weight vector W_i, maximum eigenvalue $\lambda_{\max}$, consistency index T, and consistency ratio Q, as shown in Eqs. (10)–(13). Whether the judgment matrix passes the consistency check is determined using the consistency ratio.

$$W_i = r_i / \sum_{i=1}^{n} r_i \tag{10}$$

$$\lambda_{\max} \approx \frac{1}{n} \sum_{i=1}^{n} \frac{\sum_{j=1}^{n} (a_{ij} W_j)}{W_i} \tag{11}$$

$$T = \frac{\lambda_{\max} - n}{n - 1} \tag{12}$$

$$Q = \frac{T}{K} \tag{13}$$

Objective weight calculation based on the CRITIC method. The evaluation indexes of online teaching effects are usually correlated. In this study, the objective weight is calculated through the CRITIC method. Assuming there are m schemes and each scheme contains n indexes. In this case, the evaluation matrix X can be represented, and the value of the element evaluation scheme in the matrix under the corresponding index is calculated as per Eq. (14).

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \tag{14}$$

The objective weight is calculated using the CRITIC method through the following steps:

1. Common trend processing of indexes
   When determining the risk assessment index, some negative indexes may exist, such as the quality of prefabricated parts. As the index value increases, the risk decreases. Meanwhile, as the positive index value increases, the risk increases. In the case of a co-existence of the two indexes, the computational complexity will be increased. Therefore, the indexes should be subjected to common trend processing to facilitate calculation, with Eq. (15) as the conversion formula.

$$x'_{ij} = \frac{1}{\lambda + \max\left|X_i\right| + x_{ij}} \tag{15}$$

   Where the index value is expressed by x_{ij}; the index value of common trend processing is denoted as x'_{ij}; the maximum value of the i-th index is expressed by $\max|X'|$; the coordinated coefficient is expressed by λ, generally set to 0.1. The evaluation matrix X' after common trend processing can be obtained.
2. Standardization of indexes
   Each index in the evaluation matrix X' differs in meaning and unit. Therefore, the value of each index should be converted into the same standard, with the processing method as shown in Eq. (16) where x''_{ij} denotes the index value after standardization.

$$x''_{ij} = \frac{x'_{ij} - \min(x'_{ij})}{\max(x'_{ij}) - \min(x'_{ij})} \tag{16}$$

3. Objective weight calculation of indexes
   The correlation coefficient ρ_{ij} between the standard deviation σ_i of each index and the index can be acquired through the standard matrix X''.

$$\sigma_i = \sqrt{\frac{1}{m}\sum_{j=1}^{m}(x_j^n - \bar{x}_i^n)^2}, i = 1,2,\cdots,n \tag{17}$$

$$\rho_{ij} = \mathrm{cov}(X_i^n, X_j^n)/(\sigma_i\sigma_j), i = 1,2,\cdots,n \tag{18}$$

Where the average value of the i-th index is expressed by x_{ij}''; the covariance between the i-th index and the j-th index is denoted as $\mathrm{cov}(X_i^n, X_j^n)$; the amount of information G_i contained in each index is shown in Eq. (19).

$$G_i = \sigma_i \sum_{j=1}^{n} (1-\rho_{ij}), i = 1,2,\cdots,n \tag{19}$$

Whereas the G_i value increases, the relative importance of the i-th index and the amount of information it contains also increase. Then, the objective weight β_i of the i-th index is calculated based on this value, as shown in Eq. (20).

$$\beta_i = \frac{G_i}{\sum_{j=1}^{n} G_j} \tag{20}$$

Determination of the comprehensive weight. The subjective α and objective β weight vectors are obtained by improving the AHP and CRITIC methods, respectively. The comprehensive weight consists of the two weights, and the weight of each index in the evaluation process can be fully reflected through their complementarity. The comprehensive weight ω_i can be obtained based on the principle of the minimum divisional information to ensure that the comprehensive weight ω_i of indexes is as close as α_i and β_i. The objective function is shown in Eq. (21).

$$\begin{cases} \min J(\omega) = \sum_{i=1}^{n} (\omega_i \ln \frac{\omega_i}{\alpha_i} + \omega_i \ln \frac{\omega_i}{\beta_i}) \\ s.t. \sum_{i=1}^{n} \omega_i = 1, \omega_i \geq 0 \quad i = 1,2,\cdots,n \end{cases} \tag{21}$$

This optimization model is solved to obtain the comprehensive weight, as in Eq. (22).

$$\omega_i = \frac{\sqrt{\alpha_i \beta_i}}{\sum_{j=1}^{n} \sqrt{\alpha_i \beta_i}} \tag{22}$$

The comprehensive weight vector is expressed by Eq. (23).

$$\omega = \left[\omega_1, \omega_2, \cdots, \omega_n\right]^{\mathrm{T}} \tag{23}$$

3.3 Index system

Based on the connotation of the above-mentioned "multi-interactive" online teaching evaluation index system and with reference to the traditional teaching evaluation index system in China and foreign online teaching evaluation standards, relevant experts in the fields of online education, learning analysis, and teaching evaluation in Henan Province were consulted for opinions and suggestions on modifying evaluation indexes. Finally, the basic framework for the "multi-interactive" online teaching evaluation index system was constructed.

Table 1. Quality factors of online open courses

First-Level Index	Symbol	Second-Level Index	Symbol	Index Description
Pre-class preparation	X_1	Teaching plan design	X_{11}	The teaching courseware features with vivid content, highlighted key points, and easy to understand
		Teaching resource	X_{12}	Video materials and website links are provided, and students are aroused to reflect upon questions
Video production	X_2	Video definition	X_{21}	Whether the video picture can clearly display course content information
		Sound definition	X_{22}	Whether the video sound is clear and enables users to hear the teacher's utterance clearly without excessive cognitive load
		Video subtitle	X_{23}	Whether the video is provided with subtitles and whether the courseware is made rigorously
		Video duration	X_{24}	Whether the video duration is moderate
Classroom teaching	X_3	Teaching attitude	X_{31}	Rigorous, careful, energetic, teach by personal examples and verbal instruction, and impart knowledge and cultivate talents
		Teaching objective	X_{32}	The teaching objectives are specific and definite, and teaching is carried out around such objectives
		Teaching organization	X_{33}	Teaching arrangement is appropriate, and teaching content and pace are adjusted timely.
		Teaching method	X_{34}	Enlighten, guide, and motivate students and answer their questions based on the student-centered concept
		Teaching interaction	X_{35}	Teacher–student mutual questioning interaction, and discussion, sharing, display, and mutual evaluation in the student group
		Technological capability	X_{36}	Teaching platforms are proficiently used, and information technology is effectively integrated with teaching
After-class guidance	X_4	Assignment and feedback	X_{41}	Assignments are arranged and checked, evaluation results are provided, and personalized feedback is given
		Individualized tutoring	X_{42}	The teacher provides online instruction and one-to-one or one-to-many tutoring

3.4 Data sources

The *Soil mechanics* was chosen from 10 universities in Henan Province, China, based on the *Chaoxing* platform, and 100 students were chosen from each university as experimental subjects. The online teaching of *Soil mechanics* was conducted by using the *Chaoxing* online teaching platform, and 14 second-level indexes, such as teaching plan design, teaching resource, and video definition, were collected. Questionnaires were distributed to 100 students who participated in the course to ensure the feasibility of the experiment, all of which were recovered, and the original data were described and counted. Table 2 shows the sample size, mean, and standard deviation of each analysis item when imported into the algorithm model.

Table 2. Descriptive statistics

Item	Sample Size	Mean	Standard Deviation
X_{11}	10	6.259	1.923
X_{12}	10	5.699	1.986
X_{21}	10	5.881	1.775
X_{22}	10	6.763	2.090
X_{23}	10	6.184	1.861
X_{24}	10	6.744	1.386
X_{31}	10	6.536	1.689
X_{32}	10	6.074	1.599
X_{33}	10	6.250	1.563
X_{34}	10	5.763	1.640
X_{35}	10	5.626	1.526
X_{36}	10	6.785	1.656
X_{41}	10	7.158	1.724
X_{42}	10	6.058	1.873

4 RESULT ANALYSIS

4.1 Weight determination of indexes at each level

According to relevant research results and combining the evaluation method for online teaching effect, an online teaching effect evaluation index system including four first-level indexes and 14 second-level indexes was established from aspects of pre-class preparation, video production, classroom teaching, and after-class guidance based on the principles of scientificity, operability, and practicability. Then, a three-layer index evaluation system was constructed. Next, a combination weighting–TOPSIS online teaching effect evaluation model was constructed by combining AHP, CRITIC, and TOPSIS models. First, the weight of each index was determined using the AHP–CRITIC method, and the weight values of third-level indexes were calculated, as presented in Table 3.

Table 3. Calculation results of AHP–CRITIC combined method

First-Level Index	Symbol	Second-Level Index	Symbol	AHP Weight	CRITIC Weight	Combination Weight	Ranking
Pre-class preparation	X_1	Teaching plan design	X_{11}	0.0576	0.1199	0.0897	4
		Teaching resource	X_{12}	0.0632	0.1082	0.0892	5
Video production	X_2	Video definition	X_{21}	0.0295	0.0792	0.0522	11
		Sound definition	X_{22}	0.0787	0.0232	0.0461	13
		Video subtitle	X_{23}	0.0988	0.0964	0.1052	2
		Video duration	X_{24}	0.0950	0.1041	0.1073	1

(Continued)

Table 3. Calculation results of AHP–CRITIC combined method *(Continued)*

First-Level Index	Symbol	Second-Level Index	Symbol	AHP Weight	CRITIC Weight	Combination Weight	Ranking
Classroom teaching	X_3	Teaching attitude	X_{31}	0.1220	0.0173	0.0495	12
		Teaching objective	X_{32}	0.0236	0.1091	0.0547	10
		Teaching organization	X_{33}	0.0261	0.0287	0.0296	14
		Teaching method	X_{34}	0.1146	0.0481	0.0801	6
		Teaching interaction	X_{35}	0.0769	0.0660	0.0768	7
		Technological capability	X_{36}	0.0602	0.0448	0.0560	9
After-class guidance	X_4	Assignment and feedback	X_{41}	0.0726	0.0454	0.0619	8
		Individualized tutoring	X_{42}	0.0811	0.1096	0.1017	3

4.2 TOPSIS results

The TOPSIS method aims to evaluate relative advantages and disadvantages based on the distance ranking from the evaluation object to positive and negative ideal solutions. First, the evaluation indexes were determined, and their forward trend (the greater, the better) was guaranteed. Table 4 shows the calculation results.

Table 4. Positive and negative ideal solutions

Item	Positive Ideal Solution A+	Negative Ideal Solution A–
X_{11}	9.000	3.400
X_{12}	8.940	3.080
X_{21}	8.960	3.610
X_{22}	8.900	3.590
X_{23}	8.370	3.410
X_{24}	8.780	4.490
X_{31}	8.840	3.810
X_{32}	8.410	3.600
X_{33}	7.990	3.720
X_{34}	8.890	3.300
X_{35}	7.430	3.460
X_{36}	8.870	4.530
X_{41}	8.970	3.460
X_{42}	8.190	3.000

The positive and negative ideal solutions in Table 5 are the intermediate process values when calculating the positive and negative distances (D+ and D–), and their significance is relatively small. The positive ideal solution A+ represents the maximum value of the evaluation index, whereas the negative ideal solution A– represents the minimum value of the evaluation index.

Table 5. TOPSIS-based evaluation and calculation results

Item	Positive Ideal Solution to Distance D+	Negative Ideal Solution to Distance D–	Relative Closeness C	Ranking Result
Huanghuai University	2.817	3.203	0.532	4
Henan Finance University	3.386	2.953	0.466	8
Nanyang Institute of Technology	2.363	3.678	0.609	2
PingdingshanUniversity	3.203	3.113	0.493	6
Henan Institute of Science and Technology	3.395	2.717	0.445	9
Henan Institute of Technology	3.019	2.681	0.470	7
Xinyang Agriculture and Forestry University	2.281	3.531	0.607	3
Xinxiang University	2.767	2.828	0.505	5
Anyang Institute of Technology	3.628	2.792	0.435	10
Zhengzhou University of Technology	2.053	3.881	0.654	1

In Table 5, D+ and D– represent the distances from the evaluation object to the positive and negative ideal solutions, respectively. C indicates the closeness between the evaluation object and the optimal scheme. As the value of C increases, it becomes closer to the optimal scheme. The relative closeness C of Zhengzhou University of Technology, Nanyang Institute of Technology, and Xinyang Agriculture and Forestry University was 0.654, 0.609, and 0.607, respectively, ranking the top three. The reason may be that these three universities have evident advantages in video duration, video subtitle, individualized tutoring, teaching plan design, teaching resource, and teaching method. In addition, the students surveyed in these three universities are highly satisfied with the *Soil mechanics*. According to the teaching content, the video duration also exerted very evident effects on other factors. The main reason is that different from the traditional classroom teaching method, online teaching requires teachers to design additional comprehensive classroom arrangements and rationalize the use of time to reflect the timeliness of teaching. In online learning, some learning courses are boring, all of which are about formulas and numbers, with long credit hours and teaching weeks. Students are not very interested in such courses, so they need to allocate classroom time flexibly. Teaching is for learning, and learning is for use. The continuous optimization of video subtitles showed evident effects on other factors. The main reason is that teachers can organize teaching plans scientifically and give lectures seriously, overflowing with enthusiasm, through the continuous optimization of online teaching content. When teaching online, they have clear ideas and priorities, teach knowledge with appropriate difficulty and depth, and combine theory with practice, thereby greatly agreeing with the new concept of industry development, enlightening students' thinking, and motivating their learning interests. In class, students analyze and solve problems, and their learning ability is strengthened. Moreover, student–student and teacher–student interactions are highly evident, and individualized tutoring is a relatively apparent influencing factor. The reason is that after-class performance is the best platform for teacher–student interaction. In addition, good interactions over the questions raised by the teacher in the classroom will be stimulated by arranging and checking assignments and answering questions and providing tutoring services after class. The teacher can also motivate students' autonomous learning ability. Then, students tend to give high comments on teachers in teaching evaluation. Thus, the combination weighting–TOPSIS method has advantages, such as a simple principle, easy-to-understand, and intuitive conclusions when used to comprehensively evaluate the competitiveness of the lighting industry. As an upgrade and improvement of TOPSIS, the combination weighting–TOPSIS method is effective and comprehensive, providing new ideas and methods for the evaluation of other fields.

5 DISCUSSION

Facing the new teaching model—online teaching, teachers have gone through a groping stage. Although efforts have been made in the early stage, students' perception of the online teaching effect is relatively low. After three months of practice, teachers have made great improvements in teaching methods and grasped the key and difficult teaching points, accompanied by the greatly improved evaluation of teachers' teaching methods and teaching content and the elevated overall evaluation by students. Moreover, students highly recognize teachers and their teaching activities. Despite the good consistency and continuity of schools in teaching organization and supervision, a great change in the hardware environment is not probable within a short time. This model fails to motivate students' sustained learning interests. Meanwhile, the evaluation of online teaching quality is a multi-factor, multi-objective, and multi-layer complex process. In this study, the weights of second-level evaluation indexes were calculated through the AHP and CRITIC methods. Afterward, a teaching quality evaluation system was established using the TOPSIS method from the following four aspects: pre-class preparation, video production, classroom teaching, and after-class guidance. Using the *Soil mechanics* from 10 universities in Henan Province on the *Chaoxing* platform as an example, an empirical analysis was performed. Moreover, various factors at all levels were comprehensively considered to realize the objective evaluation of experimental course teaching quality. In addition, man-made interference was reduced, and the results were highly objective and reasonable. This case provides a basis for teachers to control the teaching quality and also lays a foundation for developing and implementing the teaching quality evaluation system of relevant online courses.

6 CONCLUSIONS

Students' class attendance cannot be intuitively controlled by online teaching. Thus, the release of learning tasks before and after class has become an important means for teachers to understand students' learning situations. Through sustained training, students have developed a good habit of actively checking the completion of learning tasks, which is a remarkable effect of online teaching on students' behavioral changes. Under the online teaching model, students' learning mode has also changed. They have gradually learned the mode of communication with classmates or teachers to better master professional knowledge and complete learning tasks. In this study, the AHP method was combined with the TOPSIS method. First, the influencing indexes were classified through the AHP method, and index weights were determined. Then, a decision model for the comprehensive evaluation of college experimental teaching was established by combining the TOPSIS method, and the comprehensive experimental teaching status was subjected to decision ranking. Finally, the following conclusions were drawn: (1) The established evaluation index system for online teaching satisfaction includes four first-level indexes and 14 second-level indexes, with very excellent operability; (2) the combination weighting–TOPSIS model can be used to evaluate the online teaching effect more accurately; (3) video duration, video subtitle, and individualized tutoring are important factors influencing the online teaching effect. The expansion of the online teaching sample size and the correlation between students' online learning quality and teachers' teaching methods can be further investigated.

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