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#### Online and offline hybrid teaching evaluation and monitoring system based on hierarchical analysis method and fuzzy comprehensive evaluation algorithm

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**Abstract:** Following the global outbreak of the new coronavirus, all universities and colleges have been working hard to ensure that their students have the right to learn, and the combination of online and offline teaching mode has become the current educational norm. However, the traditional offline classroom teaching evaluation monitoring system is not suitable for the current requirements of blended teaching. Based on hierarchical analysis and fuzzy comprehensive evaluation algorithm, we explore the teaching evaluation monitoring system with multiple dimensions such as teaching quality monitoring, teaching quality evaluation, teaching feedback and improvement adapted to the hybrid teaching mode, and realise the web visualisation interface of teaching evaluation monitoring system with the help of computer technology. This new online and offline hybrid teaching reform and improve teaching quality.

**Keywords:** online and offline hybrid teaching; evaluation algorithm; teaching evaluation; monitoring system; visualisation interface design.

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#### 1 Introduction

Quality of higher education is the lifeline of higher education development, and paying close attention to teaching evaluation and monitoring is an important way of higher education development. After the outbreak of novel coronavirus pneumonia, the Chinese Ministry of Education (EB/OL, 2020) timely proposed the use of online platforms to 'suspend classes without stopping learning' and 'substantial equivalence of online and offline teaching', clearly pointing out that teaching work should be carried out steadily, while teaching evaluation and monitoring system should be increased (mainly referring to online teaching evaluation and monitoring) in order to achieve substantial equivalence of teaching. Local education departments and universities responded quickly, formulated emergency plans and online teaching programs and extensively trained teachers on online teaching means to quickly realise teaching mode transformation and ensure smooth operation of teaching (Qing et al., 2021). Through two years of teaching practice, teachers and students have adapted to and become familiar with the online classroom teaching mode, and classroom teaching has gradually shifted from traditional offline teaching mode to a hybrid teaching mode that combines online and offline teaching.

Although the online and offline teaching methods have gradually matured, the matching online and offline teaching evaluation and monitoring system has not really been established. Although traditional teaching evaluation and monitoring system are useful for the current teaching situation, they do not provide a comprehensive monitoring and evaluation of the existing online and offline. With the massive use of online and offline teaching methods in existing teaching, according to the talent training objectives and their own characteristics, universities must establish a scientific, effective, complete and convenient teaching evaluation and monitoring system of hybrid teaching mode, in order to guarantee the high quality of teaching work (Martin et al., 2019). Based on the problems of single way of teaching evaluation, the evaluation effect is not obvious, and the evaluation of teachers' teaching is not comprehensive (Cao and Huang, 2020), therefore, this paper intends to establish a hybrid teaching evaluation and monitoring system of online and offline teaching, from three aspects of teachers, students and academic affairs to ensure the accuracy and comprehensiveness of the teaching evaluation and monitoring system (Jin, 2018).

#### 2 Principles of constructing an online and offline hybrid teaching evaluation and monitoring system

The online and offline hybrid teaching evaluation and monitoring system is constructed in accordance with the following basic principles (Frazer et al., 2017; Tanis et al., 2017; Alonso-Díaz and Yuste-Tosina, 2017):

- 1 *Scientific principle*: The teaching evaluation system established must be able to correctly express the main aspects of online and offline aspects, and the selected evaluation method must be scientific and authentic.
- 2 *Objective principle*: When determining the teaching evaluation system, it should be based on objective reality as much as possible, avoiding the influence of subjective will on the construction of the teaching evaluation system as much as possible, and ensuring the objectivity of the establishment.
- 3 *Principle of completeness*: In order to improve the quality of teaching, the indicators of the evaluation and monitoring system need to objectively reflect the main influencing factors of online and offline hybrid teaching,

teaching quality and its constituents from all sides, and each indicator should be analysed comprehensively to avoid omissions.

4 *Principle of independence*: The indicators selected in the evaluation system should be independent of each other to minimize the degree of overlap between indicators, which is conducive to obtaining more accurate data.

## **3** The framework of online and offline hybrid teaching evaluation and monitoring system

Since the beginning of the epidemic, various efficient teaching models have been used to teach online or offline in response to the severity of the epidemic. The online teaching mode mainly uses 'Internet+' technology (Zhang, 2016), and adopts online platforms such as Mooc, Love the course, Wisdom Tree, Learning through, School online and Nail class to teach. The offline teaching mode is still mainly using the traditional teaching method, i.e., teaching in the classroom. Considering that the teaching environment and teaching methods of both online and offline teaching modes are different, a hybrid evaluation of online and offline teaching modes should be conducted to achieve comprehensiveness and accuracy of evaluation. At the same time, the roles and responsibilities of teachers, students and academic affairs in the whole teaching model are different, and there are direct and indirect links among the three, so they are evaluated from three aspects in order to achieve the integrity of the evaluation system.

The teaching evaluation and monitoring system of teacher side is carried out from three aspects: before, during and after the class. The framework of the evaluation and monitoring system is presented below for three aspects: teachers, students and academic affairs (Li and Hao, 2017).

In the whole evaluation system, the role of teachers in imparting knowledge to students, because the teaching method of teachers is directly related to whether students understand the knowledge of what they have learned, so it is necessary to evaluate the teaching method of teachers to get the teaching efficiency and teaching quality of teachers (Richardson et al., 2016). Based on consideration, teacher will be evaluated in three aspects. The first aspect is classroom teaching, where students can evaluate the teachers' performance in each class, and experts from the academic affairs can also come over to listen to the classes and evaluate the teaching style and quality of teaching. The second aspect is the pre-course and post-course, mainly the extent of the teacher's role and supervision in the pre-course pre-reading stage and the extent of correction and tutoring in the postcourse stage. The final examination is still the most intuitive and reliable quantitative indicator for evaluating the effectiveness of classroom teaching, and must be integrated into the established index system to ensure the objectivity and integrity of the established teaching evaluation and monitoring system. The online and offline hybrid teaching evaluation and monitoring system about teacher side is shown in Table 1.

Level 1 indicators B	Secondary indicators C
Classroom	Student Evaluation $C_1$
teaching $B_1$	Academic Affairs Evaluation $C_2$
Pre-learning before class $B_2$	Pre-lesson supervision efforts $C_3$
Review after class $B_3$	Extent of after-school homework help $C_4$
	Grade average $C_5$
Final grades	Achievement variance $C_6$
$D_4$	Excellent rate $C_7$
	Level 1 indicators B Classroom teaching $B_1$ Pre-learning before class $B_2$ Review after class $B_3$ Final grades $B_4$

Students are the main subject of the whole teaching

 Table 1
 Online and offline hybrid teaching evaluation and monitoring system: teacher side

Table 2	Online and offline hybrid teaching evaluation and
	monitoring system: student side

	0 1	
Evaluation objectives X	Level 1 indicators Y	Secondary indicators Z
		Pre-class preview completion rate $Z_1$
	Online classroom	Pre-class homework score $Z_2$
	quanty 1	Quality of communication before class $Z_3$
Student side	Offline classroom	Class activity $Z_4$
~~~~~~		Classroom interaction effect $Z_5$
	performance $Y_2$	Finish homework after class $Z_6$
	Final exam $Y_3$	Score ranking $Z_7$
	Teacher's	Learning attitude $Z_8$
	opinion $Y_4$	Attendance rate in class $Z_9$

## 4 Teacher side teaching evaluation monitoring system

#### 4.1 Hierarchical analysis for the weight assignment of teacher-side online and offline hybrid teaching evaluation and monitoring system

Commonly used methods for assigning indicators include hierarchical analysis, principal component analysis, entropy weighting, combined weighting, etc. Among them, principal component analysis and entropy weighting are mainly used in the case of large amount of indicator data. Considering the small amount of data and the large number of qualitative evaluation indexes in the 'online + offline' integrated teaching evaluation and monitoring system, this paper chooses hierarchical analysis as the main weighting method. Hierarchical analysis (Feng et al., 2017) is a system analysis method proposed by Saaty, an expert in operations research at the University of Pittsburgh in the 1970s, which uses a combination of qualitative and quantitative approaches to deal with various decision factors and has the advantages of being systematic, flexible and concise and thus has been widely used in various fields. The main idea is to decompose the required objectives into multiple constituent factors according to the nature of the research object, and to hierarchise them according to the affiliation between factors to form a hierarchical structure model, and then to analyse them by level, compare the importance of each factor in the same level compared with the factor in the previous level, and construct a weight judgment matrix. Finally, the importance weight of the bottom factor to the top (total goal) is obtained or ranked in order of superiority or inferiority, as shown in Figure 1.

evaluation system, the main factor to judge whether the teaching evaluation and monitoring system is in line with the actual situation, and the main purpose of constructing the teaching evaluation and monitoring system. Students need to be evaluated objectively and scientifically from multiple perspectives in order to achieve completeness and accuracy in the evaluation of students. Based on a comprehensive analysis and consideration, students should be evaluated in four aspects: online classroom quality, offline classroom quality, final grades and teacher opinions. Online classroom performance mainly includes three aspects: completion rate of pre-class prep, pre-class homework performance and pre-class communication quality. The offline classroom performance is mainly evaluated in terms of classroom activity, classroom interaction and completion of assignments after class. The final exam results are used as quantitative indicators for teaching quality evaluation to enhance the objectivity of teaching evaluation; Teachers 'opinions are evaluated based on the students' learning attitude and class attendance rate. The online and offline teaching evaluation and monitoring system about student side is shown in Table 2.

Academic affairs have the highest management authority in the teaching evaluation and monitoring system, and can check the specific evaluation of teachers and students in the whole evaluation system, therefore, academic affairs should play a supervisory role for students and teachers in the whole evaluation process. The role of teaching affairs in the evaluation includes teacher teaching evaluation, course evaluation and feedback, etc. Teacher teaching evaluation is mainly the evaluation of teachers' preparation before class and teaching process during class, course evaluation is mainly the evaluation of teachers' teaching methods in teaching courses. The feedback mainly evaluates the effect of the online and offline hybrid teaching from the perspective of teachers and students, which can enhance the comprehensiveness of the teaching quality evaluation.

Figure 1 Flow chart of hierarchical analysis method



The 1–9 scale was used to compare the importance of each factor in the same level relative to its upper level in a two-bytwo comparison, and the 1-9 scale is shown in Table 3. Constructing the weight judgment matrix and assigning values to the degree of importance, the following indicators that affect the teacher teaching evaluation and monitoring system are assigned with the degree of importance respectively, and constructing the weight judgment matrix.

**Table 3**1–9 Scaling method as shown in the table

Scale	Level of importance of the two indicators compared to each other
1	Both indicators have the same importance
3	The former is slightly more important than the latter
5	The former is significantly more important than the latter
7	The former is extremely more important than the latter
9	The former is more strongly important than the latter
2, 4, 6, 8	Indicates the middle value of the above adjacent judgments
Countdown from 1–9	Indicates the importance of comparing the corresponding two indicators in order of exchange

$$A = \begin{bmatrix} 1 & 3 & 5 & 3 \\ \frac{1}{7} & 4 & \frac{1}{5} & \frac{1}{3} \\ \frac{1}{4} & 2 & 1 & 2 \\ \frac{1}{2} & 5 & 3 & 1 \end{bmatrix} B_{1} = \begin{bmatrix} 1 & 2 \\ \frac{1}{2} & 1 \end{bmatrix}$$
$$B_{2} = \begin{bmatrix} 1 \end{bmatrix} B_{3} = \begin{bmatrix} 1 \end{bmatrix} B_{4} = \begin{bmatrix} 1 & \frac{1}{3} & \frac{1}{2} \\ 3 & 1 & 2 \\ \frac{1}{2} & \frac{1}{2} & 1 \end{bmatrix}$$

Judgment matrix based on the constructed weights. The maximum eigenvalue of the judgment matrix  $\lambda_{max}$  is obtained from equation. The corresponding feature vector  $W = (W_1, W_2, ..., W_n)^T$  is found according to the corresponding formula  $AW = \lambda W$ , which is the calculated index weight. In addition to this, the indicator weights need to be further normalised so that the cumulative sum of the feature vector elements corresponding to the same feature value is 1, that is  $\sum_{i=1}^{n} w_i = 1$ . According to the constructed

judgment matrix, the weight result of each indicator of the teacher is calculated as follows:

$$W_{A} = \begin{bmatrix} 0.4338 & 0.108 & 0.1835 & 0.2746 \end{bmatrix}$$
$$\begin{bmatrix} 0.6667 & 0.3333 \end{bmatrix}$$
$$W_{B2} = \begin{bmatrix} 1 \end{bmatrix}$$
$$W_{B3} = \begin{bmatrix} 1 \end{bmatrix}$$
$$W_{B4} = \begin{bmatrix} 0.1826 & 0.5900 & 0.2273 \end{bmatrix}$$

After getting the weights of each index through the above steps, the consistency test is started, because when comparing the factors of the teaching evaluation and monitoring system between two, it is difficult to achieve a completely consistent metric and there may be certain errors, and in order to increase the reliability of the weight evaluation, The consistency check algorithm is

$$CR = \frac{CI}{RI} \tag{1}$$

where,  $CI = \frac{\lambda_{\text{max}} - n}{n - 1}$ , *n* is the dimension of the matrix and *RI* takes the values shown in Table 4.

Table 4Table of the values of RI

Dimension	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.96	1.12	1.24	1.32	1.41	1.45

If CR < 0.1, the judgment matrix is considered to meet the consistency requirement, and the above matrices are calculated to meet the consistency requirement.

Calculate the comprehensive weights of the secondary indicators compared to the evaluation objectives. By combining the relative weights of the primary and secondary indicators, the comprehensive weights of the secondary indicators can be obtained. Because in the above calculation to find the weight of the primary indicators is  $W_{Ai} = (W_{A1}, W_{A2}, ..., W_{Ai}, ..., W_{An}), w_i$  is the relative weight value of the first level indicator *i* at the criterion level. Assume that the weight of the secondary index under the *k*-th primary index is:

$$W_{Bkj} = \left(w_{Bk1}, w_{Bk2}, ..., w_{Bki}, ..., w_{Bkn}\right)$$
(2)

Then, the weight of secondary index j under primary index i is:

$$W_{AiBij} = W_{Ai} \bullet W_{Bij} \tag{3}$$

The comprehensive evaluation weight of teachers can be obtained by substituting the solution,  $W_{AiBij} = [0.2892, 0.14460.108, 0.1835, 0.0501, 0.1620, 0.0624]$ . From the calculation results, we can see the share weight of each indicator in the total ranking, where  $W_{A1B11}$  represents the mean value of the final exam  $(C_1)$  indicator with a weight value of 0.2892, indicating that student evaluation in classroom teaching has the greatest importance among all indicators, which is mainly due to the fact that students are the main body in the whole teaching process, and students' mastery of knowledge is the most powerful indicator to evaluate teachers. Therefore, the credibility is greater.

#### 4.2 Comprehensive evaluation of fuzzy comprehensive evaluation algorithm on online and offline hybrid evaluation and monitoring system

The fuzzy comprehensive evaluation method (Chen, 2018) is a comprehensive bid evaluation method based on fuzzy mathematics. This comprehensive evaluation method converts qualitative evaluation into quantitative evaluation according to the affiliation theory of fuzzy mathematics, i.e., it uses fuzzy mathematics to make an overall evaluation of things or objects that are constrained by multiple factors. It has the characteristics of clear and systematic results, so it can better solve fuzzy and difficult to quantify problems, and is suitable for solving various non-deterministic problems. The concept of fuzzy set theory was proposed in 1965 by Professor L.A. Zadeh, an American automatic control expert, to express the uncertainty of things, so it has been widely used in various fields. It is mainly divided into two steps: the first step is to evaluate each factor individually; the second step is to evaluate all factors together. The advantage of fuzzy comprehensive evaluation is that the mathematical model is simple and easy to grasp, and it is more effective in judging complex problems with multiple factors and levels (Zhou et al., 2017), which is a difficult method to be replaced by other mathematical branches and models.

In order to realize the purpose of online and offline hybrid teaching evaluation and monitoring system of fuzzy comprehensive evaluation algorithm, firstly, on the basis of analytic hierarchy process, a set of n factors affecting the evaluation of teaching quality is established, which is called the factor set  $U = \{u_1, u_2, u_3, ..., u_n\}$ . The factor sets at different levels correspond to different indicators. Then establish  $W = \{w_1, w_2, w_3, ..., w_n\}$ the weight set corresponding to each factor. The index weights of teachers and students have been calculated in the above text. Finally, a set of comments at different levels  $V = \{v_1, v_2, v_3, \dots, v_n\}$ , is established. Comments are qualitative descriptions of the advantages and disadvantages of evaluation objects. On the basis of the factor set and the comment set, construct the comment fuzzy matrix  $R = (r_{ij})_{n \times m}$  of the indicators at each level, that is, get the comprehensive evaluation matrix  $B = W \times R$  and compare the results with the comment set to achieve a comprehensive evaluation of each object. The fuzzy comprehensive evaluation algorithm is shown in Figure 2.

Figure 2 Flow chart of fuzzy comprehensive evaluation algorithm



The indicators that affect teachers have been listed above, which can be used as the factor set of fuzzy comprehensive evaluation algorithm, that is, the factor set={classroom teaching, pre-class preview, after-class review, final grade}. In the process of fuzzy comprehensive evaluation, the number of grades of the comment set is generally greater than or equal to 4 but not more than 9. In the process of evaluating the teaching quality of teachers, the comment set selects four grades and the comment set is {excellent, good, medium, poor}.

Taking the construction of our new engineering specialty as an opportunity, and taking the certification standard of engineering education specialty as the basic criterion, we carried out research in our school, investigated the teaching evaluation quality of students and teachers in school, established a teacher's teaching evaluation and monitoring system based on it, and established a fuzzy evaluation matrix as shown in Table 5. As shown in Table 6, the grade and the corresponding score column are matched one by one, so that we can see which grade the teacher's teaching level is at, and then better improve the teaching quality.

Table 5Fuzzy evaluation matrix

Target layer	Weights	Indicator layer	Weights	Teaching quality evaluation grade				
				Excellent	Good	Medium	Poor	
D1	0 4228	C1	0.2892	0.3	0.5	0.1	0.1	
DI	DI 0.4338	DI 0.4558	C2	0.1446	0.2	0.5	0.3	0
B2	0.1080	C3	0.1080	0.6	0.3	0.1	0	
В3	0.1835	C4	0.1835	0.4	0.4	0.1	0.1	
		C5	0.0501	0.3	0.3	0.2	0.2	
B4	0.2746	C6	0.1620	0.7	0.2	0.1	0	
_		C7	0.0624	0.2	0.4	0.3	0.1	

**Table 6**Grade and corresponding score table

Evaluation Level	Excellent	Good	Medium	Poor
Score	100	85	70	55

According to Table 5, the single factor fuzzy evaluation matrix is:

R _	0.3	0.5	0.1	0.1
$\Lambda_1 =$	0.2	0.5	0.3	0
$R_2 =$	[0.6	0.3	0.1	0]
$R_3 =  $	[0.4	0.4	0.1	0.1]
	0.3	0.3	0.2	0.2]
$R_{4} =$	0.7	0.2	0.1	0
	0.2	0.4	0.3	0.1

According to the above analytic hierarchy process, the weights of various factors and indicators affecting teachers' teaching evaluation are  $W_{B1} = \begin{bmatrix} 0.6667 & 0.3333 \end{bmatrix}$ ,  $W_{B2} = \begin{bmatrix} 1 \end{bmatrix}$ ,  $W_{B3} = \begin{bmatrix} 1 \end{bmatrix}$ ,  $W_{B4} = \begin{bmatrix} 0.1826 & 0.5900 & 0.2273 \end{bmatrix}$ .

According to the formula, the fuzzy comprehensive evaluation value of each factor can be obtained as follows:

$$E_{1} = \begin{bmatrix} 0.2667 & 0.5 & 0.1667 & 0.0667 \end{bmatrix}$$
$$E_{2} = \begin{bmatrix} 0.6 & 0.3 & 0.1 & 0 \end{bmatrix}$$
$$E_{3} = \begin{bmatrix} 0.4 & 0.4 & 0.1 & 0.1 \end{bmatrix}$$
$$E_{4} = \begin{bmatrix} 0.5132 & 0.2637 & 0.1637 & 0.0593 \end{bmatrix}$$

According to the above single-factor fuzzy comprehensive evaluation value  $E_i$ , the comprehensive fuzzy evaluation matrix of teacher quality evaluation can be obtained as follows:

	0.2667	0.5	0.1667	0.0667	
D _	0.6	0.3	0.1	0	
Λ =	0.4	0.4	0.1	0.1	
	0.5132	0.2637	0.1637	0.0593	

At the same time, the comprehensive index weight of the four factor sets of teaching quality evaluation is  $W_A = \begin{bmatrix} 0.4338 & 0.108 & 0.1835 & 0.2746 \end{bmatrix}$ . According to the formula  $B = W \bullet R$ , the comprehensive fuzzy evaluation value can be obtained as follows:

 $B = \begin{bmatrix} 0.3948 & 0.3951 & 0.1464 & 0.0636 \end{bmatrix}$ 

According to the principle of maximum affiliation, because the largest value in the comprehensive fuzzy evaluation value is 0.3951, the evaluation grade for this teacher is good and the corresponding score is 85. Using the fuzzy comprehensive evaluation method for teacher teaching evaluation is exactly the same as the actual evaluation grade of this teacher, so this evaluation method can be used as a way to evaluate the teaching quality of teachers with certain practicality.

## 5 Student side teaching evaluation monitoring system

In the above, the weight distribution of teachers' teaching quality evaluation is based on the hierarchical analysis method, because the hierarchical analysis method decomposes the evaluation object into different factors according to the nature of the evaluation object and the total goal to be achieved, and gathers and combines the factors according to different levels according to the interrelated influence of the factors and the subordinate ones.

A multi-level analysis structure model is formed, so that the problem finally boils down to the determination of the relative importance weight of the lowest level relative to the highest level or the ranking of the relative order of merit, and the main source of the evaluation of students is the composition of multiple factors, the calculation and ranking of each factor, so as to obtain the weight value of each factor on the evaluation of students. Therefore, the evaluation of students is also conducted using hierarchical analysis, and the results obtained through this method of evaluation are somewhat comprehensive and accurate.

In the evaluation system of students, it is known from the above that the influencing factors are mainly composed of 4 primary indicators and 9 secondary indicators. From the steps of the hierarchical analysis method above, each indicator is first scaled using the 1–9 scale method, and the importance of each factor in the same level relative to its upper level is compared between two, and the importance of each factor indicator is assigned to get the weight judgment matrix.

$$X = \begin{bmatrix} 1 & \frac{1}{5} & \frac{1}{2} & \frac{1}{3} \\ 5 & 1 & 3 & 2 \\ 2 & \frac{1}{3} & 1 & \frac{1}{2} \\ 3 & \frac{1}{2} & 2 & 1 \end{bmatrix} \qquad Y_1 = \begin{bmatrix} 1 & 3 & 2 \\ \frac{1}{3} & 1 & \frac{1}{2} \\ \frac{1}{2} & 2 & 1 \end{bmatrix}$$
$$Y_2 = \begin{bmatrix} 1 & 3 & 2 \\ \frac{1}{3} & 1 & \frac{1}{2} \\ \frac{1}{3} & 1 & \frac{1}{2} \\ \frac{1}{2} & 2 & 1 \end{bmatrix} \qquad Y_3 = \begin{bmatrix} 1 \end{bmatrix} \qquad Y_4 = Y_4 = \begin{bmatrix} 1 & 5 \\ \frac{1}{5} & 1 \end{bmatrix}$$

Using the above steps of hierarchical analysis used for teachers, the weights of the factors affecting student evaluation were assigned. the eigenvectors corresponding to the maximum eigenvalues of each matrix were calculated according to the weight judgment matrix, and the eigenvectors were normalised, after which the weights of each index were tested for consistency to determine whether the obtained weight assignments met the requirements, and finally, the above matrices were calculated to be the above matrix meets the consistency requirement.

Because in the process of evaluating students, there are both primary and secondary indicators, so in order to get the index weights of comprehensive evaluation, we need to multiply the primary indicators with the secondary indicators belonging to them to get the comprehensive weight values of secondary indicators, and the results of the solution are  $W_{AiBii} = [0.0473, 0.0144, 0.0262, 0.2606, 0.0789, 0.1434,$ 0.1570, 0.2267, 0.0453]. From the calculation results, we can see the weight of each indicator, among which the classroom activity in the offline classroom performance and the learning attitude in the teacher's opinion have the largest weight value, which is actually in line with the actual a teaching situation, students only have a good attitude and learning condition in the classroom, in order to master the course knowledge more proficiently, followed by the ranking of the final exam, this indicator is able to well This indicator is a good reflection of students' learning situation in an academic year. From the actual situation to analyse the index weights, we can see that the weight ratio is still in line with the actual situation, so it has a certain practicality.

#### 6 Visual interface implementation of online and offline hybrid teaching evaluation and monitoring system

#### 6.1 Introduction of visual interface technology for online and offline hybrid teaching evaluation and monitoring system

In the above, the framework of the online/offline hybrid teaching evaluation and monitoring system was constructed and the individual index weights were assigned to teachers and students separately using hierarchical analysis. Based on the obtained results, the online and offline hybrid teaching visualisation interface was implemented by programming. The programming languages used in this process are mainly HTML, CSS and JavaScript to implement the visual interface (Han, 2021), and their roles and connections are described below.

HTML, whose full name is Hypertext Markup Language, is a markup language that is mainly used to describe web pages, and it includes a series of tags. These tags allow the formatting of documents on the Web to be unified, connecting scattered Internet resources into a logical whole.HTML text is a descriptive text consisting of HTML commands, which can describe text, graphics, animations, sounds, tables, links, etc.

CSS, called Cascading Style Sheets, is a document that specifically describes the way a structured document is realized and is mainly used for web page styling, including font size, colour and precise positioning of colours. The use of CSS in web design can make monotonous HTML pages more expressive. CSS is also used to separate document formatting from style, making it easier to manage and modify web pages.

JavaScript is an advanced scripting language for the web that not only creates objects, but also uses existing objects to add a variety of dynamic features to web pages, providing a smooth and beautiful experience. The combination of these three components results in a complete web page that can be used by teachers, students and faculty for online and offline teaching and evaluation (Tezer and Çimşir, 2018).

#### 6.2 Display of visual interface of online and offline hybrid teaching evaluation and monitoring system

The interface design of the envisioned online and offline teaching evaluation and monitoring system is carried out through the above-mentioned techniques (Luo, 2022) to achieve the purpose that the idea can be verified through practice. The entire interface is designed for teaching and evaluation of teachers, students and academic affairs, and is roughly divided into login functions for different identities, teaching and evaluation functions and management functions, which are described below.

Because the designed interface is mainly for serving teachers, students and educational administration, first of all, according to the different identities of users, the relevant identities of loggers are distinguished when logging in to the web page, which makes the loggers use different functions due to different identities. At the same time, the login interface is also designed with the function of remembering passwords and registering accounts, which can make the entire login interface meet our actual use needs. The schematic distribution of the visual interface structure is shown in Figure 3.

### Figure 3 The schematic distribution of the visual interface structure



When the user's account and password are entered correctly, the user will enter the home page of the main interface, the interface style of the main interface is shown in Figure 4 below. The whole main interface mainly divides teaching and evaluation into seven modules: home, online teaching, offline teaching, course evaluation, final exam, class management and user management and each module has corresponding functions underneath. The following is a brief introduction of the functions of each module.

Figure 4 Diagram of the interface of the online and offline evaluation system

A Construction of the second s	Home page	Pre-class preview Classwork	Ssue release Teaching platfor	🗭 rm Forum center L	earning materials Student feed	back	Current user: n	nark Identity: s Time:202	udent Quit [→ 3/4/12/ 16:53:58 Wec
😂 Home page	👔 Pre-class pre	view					🕞 Add	🖨 Back 🔿	March  🎁 Refresh
	College class		Professional subjects		Semester	All	~		🔎 Query
😂 Online teaching	0	College class	Professional subjects	Teacher	Preview progress	1	Preview results		Dperation
	Ом	echanical Design Class 1	machine design	Wang An	80%		75	view edit	examine Reporting
Offline teaching	Ом	echanical Design Class 1	machine design	Wang An	80%		75	view edit	examine Reporting
	Ом	echanical Design Class 1	machine design	Wang An	80%		86	view edit	examine Reporting
Course evaluation	О м	echanical Design Class 1	machine design	Wang An	80%		89	view edit	examine Reporting
	Ом	echanical Design Class 1	machine design	Wang An	80%		78	view edit	examine Reporting
💾 Student achievement	Ом	echanical Design Class 1	machine design	Wang An	80%		80	view edit	examine Reporting
	Ом	echanical Design Class 1	machine design	Wang An	70%		70	view edit	examine Reporting
Ar Class management	О м	echanical Design Class 1	machine design	Wang An	88%		50	view edit	examine Reporting
	Ом	echanical Design Class 1	machine design	Wang An	84%		68	view edit	examine Reporting
••• User management	Ом	echanical Design Class 1	machine design	Wang An	85%		72	view edit	examine Reporting
	Ом	echanical Design Class 1	machine design	Wang An	90%		76	view edit	examine Reporting
	Ом	echanical Design Class 1	machine design	Wang An	80%		80	view edit	examine Reporting
	Ом	echanical Design Class 1	Machining process	Wang An	70%		90	view edit	examine Reporting
	Ом	echanical Design Class 1	Machining process	Wang An	80%		86	view edit	examine Reporting
	Ом	echanical Design Class 1	Machining process	Wang An	80%		88	view edit	examine Reporting
	Ом	echanical Design Class 1	mechanical principle	Wang An	80%		84	view edit	examine Reporting
	О м	echanical Design Class 1	mechanical principle	Wang An	80%		80	view edit	examine Reporting

The second module is mainly online teaching, which refers to the online teaching by teachers through some teaching software. The online teaching block mainly contains functions such as pre-course preview, classroom assignments, problem posting, teaching platform, forum centre, learning materials and student feedback, through which teachers can play a more complete monitoring and evaluation mechanism on the whole online class status of students, and students can interact online especially when they encounter problems they do not understand in the learning process (Croxton, 2019), and can post problems in the problem posting module Posting the problems they do not understand, and the students can consider and solve the problems together through the forum centre.

After that is the offline teaching for classroom lessons, which is the main way for teachers to carry out teaching activities. Offline teaching mainly includes functional modules such as pre-course prep, pre-course practice, classroom quality, post-course consolidation, exchange and discussion, learning materials and student feedback. Offline teaching provides a comprehensive grasp of students' learning from before, during and after class, allowing students to have a more solid grasp of what they have learned. The whole process not only allows teachers to teach more comprehensively, but also allows students to interact with teachers and classmates during the learning process.

The next module is course evaluation. Course evaluation mainly refers to the evaluation of teachers' teaching by students and faculty, which mainly includes teaching style, teaching attitude, teaching effect, teaching content and feedback. The course evaluation involves all aspects of the teacher's teaching situation, which can achieve fairness in the evaluation of teachers. The next section is student achievement, which provides a comprehensive evaluation of students' usual grades and final grade. The main modules of student grades include pre-class grades, class grades, attendance grades, homework grades, final grades, overall grades and class ranking. Through this interface, students can have a clear view of their grades, and this also includes the teacher's evaluation of the students, so that it is somewhat subjective and the students' grades are more comprehensive and fair.

Because students will choose courses according to their personal preferences and also need to pay attention to course instructor information and exam information, the next section is class management. The main modules included in class management are online class selection, class selection result inquiry, semester class schedule, teacher introduction, exam information and student feedback. By adding these functions into the designed system, it can make the whole designed interface more complete and practical.

The last module is user management, which is mainly to organise and summarize the information of loggedin people. The main modules included in class management are basic information, information modification, information verification, password modification and student feedback. The user management module will store everyone's information in the database and assign functions for people with different identities, where teachers and students can find and modify their personal information, so that different people can evaluate the teaching differently, and finally it will be possible to This way, teachers and students can find and modify their personal information, so that different people can evaluate the teaching and learning, and finally, teachers and students can be evaluated by the assigned index weights, and the design requirements can be achieved. The visualisation interface of the online and offline teaching evaluation and monitoring system framework is built through HTML, CSS and JavaScript technologies and several functions are built according to the actual teaching situation. Based on the overall framework of the visualisation interface, the specific implementation of each function can be built with the help of database and data processing visualisation to meet the actual teaching use.

#### 7 Conclusion

With the continuous development of information technology, the application of online and offline hybrid teaching mode is becoming more and more widespread. In this paper, based on the principle of index system construction, teachers, students and academic affairs are taken as the objects of evaluation according to the existing teaching evaluation, and the factors affecting teaching evaluation are considered comprehensively and incorporated into the evaluation system to build the framework of teaching evaluation and monitoring system. The teachers are evaluated by the hierarchical analysis method and fuzzy comprehensive evaluation method, and the students are evaluated by the hierarchical analysis method, and the index weights are assigned. Finally, the HTML, CSS and JavaScript technologies are used to design the visualisation interface of the teaching evaluation and monitoring system based on the constructed framework of the teaching evaluation and monitoring system. The teaching evaluation and monitoring system designed in this paper has been formally used in our college locally, and has achieved certain teaching effects. However, the method and evaluation index of teaching evaluation have certain limitations. Therefore, in the future research direction, we will further deepen the teaching evaluation method and the criteria of teaching evaluation and monitoring system, so as to improve the effect and quality of teaching evaluation in an all-round way.

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#### References

- Alonso-Díaz L. and Yuste-Tosina, R. (2017) 'Constructing a grounded theory of e-learning assessment', *Educational Computing Research*, Vol. 53, No. 3, pp.315–44.
- Cao, R. and Huang, H. (2020)' During the epidemic, online teaching triggered thinking on offline teaching', *Science and Technology*, Vol. 422, No. 72.

- Chen, S. (2018) 'Research on teachers' teaching quality evaluation based on fuzzy theory', *Practice and understanding of mathematics*, Vol. 41, No. 6, pp.75–76.
- Croxton, R.A. (2019) 'The role of interactivity in student satisfaction and persistence in online learning', *MERLOT Journal of Online Learning and Teaching*, Vol. 10, No. 2, pp.314–25.
- EB/OL (2020) Central Committee of the Communist Party of China and the State Council. Overall Plan for Deepening the Reform of Educational Evaluation in the New Era [EB/OL] (2020-10-13) [2021-10-01]. Available online at: http://www.gov.cn/
- Feng, L., Sui, S. and Du, W. (2017) 'Teaching evaluation index model based on AHP', *Journal of Northwest Normal University* (*Natural Science Edition*), Vol. 46, No. 5, pp.20–23.
- Frazer, C., Sullivan, D.H., Weatherspoon, D. and Hussey, L. et al. (2017) 'Faculty perceptions of online teaching effectiveness and indicators of quality', *Nursing Research and Practice*.
- Han, D. (2021) 'Application of HTML5 in mobile learning platform design', *Wireless Internet Technology*, Vol. 18.
- Jin, Y. (2018)'Research on the evaluation index system of 'excellent teachers' teaching skills', *Journal of Henan* University of Science and Technology. Vol. 2.
- Li, F. and Hao, X. (2017) 'Construction and practice of hybrid teaching quality evaluation system', *China Audio-visual Education*, Vol. 11, pp.108–113.
- Luo, W. (2022) 'Analysis of teaching innovation in computer web design course', *Electronic Technology*, Vol. 9.
- Martin, F., Ritzhaupt, A. and Kumar, S. et al. (2019) 'Awardwinning faculty online teaching practices: course design, assessment and evaluation, and facilitation', *The Internet and Higher Education*, Vol. 42, pp.34–43.
- Qing, L., Qu, J. and Wen, C. et al. (2021)'Research on the teaching effect of live broadcast courses under the COVID-19', *Industry and Technology Forum*. Vol. 3.
- Richardson, J.C., Besser, E., Koehler, A., Lim, J. and Strait, M. et al. (2016) 'Instructors perceptions of instructor presence in online learning environments', *International Review of Research in Open and Distributed Learning*, Vol. 17, No. 4.
- Tanis, C.J. (2017) 'The seven principles of online learning: feedback from faculty and alumni on its importance for teaching and learning', *Research Learning Technology*, Vol. 28, pp.1–25.
- Tezer, M. and Çimşir, B.T. (2018) 'The impact of using mobile-supported learning management systems in teaching web design on the academic success of students and their opinions on the course', *Interactive Learning Environments*.
- Zhang, Y. (2016) 'Analysis of the concept and mode of 'internet plus education', *China Higher Education Research*, Vol.2, pp.70-73.
- Zhou, L., Li, H. and Sun, K. (2017) 'Teaching performance evaluation by means of a hierarchical multifactorial evaluation model based on type 2 fuzzy sets', *Applied Intelligence*, pp.1–11.
- Zhou, S. and Liu, Z. (2020) 'Challenges and countermeasures of offline teaching in the context of epidemic prevention and control', *Journal of Tonghua Normal University*, Vol. 4.