Teaching Quality Evaluation Model of University Teachers Based on Neural Network

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Abstract. Considering the structural characteristics and the adaptive and self-learning functions of neural networks, a teaching quality evaluation system for high-level teachers was developed using the BP neural algorithm. The system's mathematical model was established, with each evaluation index serving as input and teaching effectiveness as output. The model demonstrated feasibility and applicability in terms of convergence speed and network adaptability. Experimental results indicated that the mathematical model effectively addressed the complexity and interference of human factors in traditional analysis and evaluation of teaching processes. The model exhibited features such as convenience, accuracy, reliability, and speed, with high identification accuracy.

Keywords: university teachers; teaching quality; BP neural network; Evaluation index;

1 Introduction

The quality assurance system of higher education places great importance on the teaching quality of college professors, which serves as a crucial aspect indicating their teaching proficiency[1-3]. Evaluating the teaching quality of professors enables the educational management department to gain a systematic, comprehensive, and accurate understanding of the teaching standards and quality across various courses. This evaluation process also helps identify effective teaching practices and areas that require improvement, facilitating timely teaching reforms and providing a solid foundation for decision-making[4-5]. Moreover, by gathering students' objective feedback on professors' teaching, evaluations offer valuable information for professors to enhance their teaching methods and ultimately enhance the overall teaching quality. Furthermore, evaluations contribute to the cultivation of a group of outstanding professors, particularly beneficial in nurturing young teachers and supporting their professional development. As a result, the overall competency of the teachers is enhanced. This helps improve the quality of teaching and the effectiveness of student learning[6-8].

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2 The establishment of teacher teaching quality evaluation index system

2.1 Contents of the teaching quality evaluation index system

The teacher teaching quality evaluation index system mainly consists of the following elements: Six first-level indicators, including teaching concept, the execution of the curriculum and teaching schedule, teaching content, teaching tactics, teaching culture and fundamental teaching skills, as illustrated in Table 1.

Table 1. Teacher teaching quality evaluation index system

Primary index	Secondary index
Teaching idea	Possessing modern educational ideas and strong innovative concepts (X1)
	Having a strong consciousness of educational reform and cultivating their unique teaching approach (X2)
The execution of the curriculum and teaching schedule	Align educational and subject objectives with curriculum requirements (X3)
	Fulfill the teaching duties and matters outlined in curriculum (X4)
	Consistently and systematically implement the prescribed learning content (X5)
	Follow the teaching schedule without unauthorized alterations (X6)
Teaching content	The teaching content is well-organized, emphasizing key points and difficulties (X7)
	The knowledge level taught is presented in a clear and logical manner (X8)
	New knowledge, theories, and skills are introduced in a timely manner during classroom teaching (X9)
	There is a focus on cultivating students' practical and innovative abilities, and importance is placed on related skills development for the curriculum (X10)
Teaching tactics	Teaching tactics are chosen based on the characteristics of the course, with a focus on being people-oriented, promoting active learning and teaching (X11)
	Flexibility and variety in teaching methods are employed to engage students, fostering their sense of participation and innovative thinking (X12)
	Modern teaching methods are used in a reasonable manner, delivering vivid lectures (X13)
Teaching culture	Teachers play a crucial role in shaping students' sense of responsibility, moral conduct, and academic rigor (X14)
	They demonstrate patience in addressing students' queries, tailor their teaching to individual aptitudes, and provide effective guidance (X15)
	Teachers value the diversity among students and encourage their enthusiasm for learning (X16)
	In the classroom, teachers foster a harmonious relationship with students, creating a lively and well-organized atmosphere (X17)
Fundamental teaching skills	Accurate, fluent and clear language expression, proficient in Mandarin teaching (X18)
	Board writing design is reasonable, concise, neat, standard writing (X19)
	Natural, dignified, generous, friendly, neat dress (X20)
	Teachers allocate time for each teaching segment in a scientific and reasonable manner, ensuring high efficiency in classroom instruction

	(X21) They adhere to punctuality, arriving and departing from class on time, without any tardiness or early departure (X22)

3 Case analysis of teachers' teaching quality evaluation

The teaching quality evaluation index system consists of 22 second-level evaluation indicators (X1 to X22) that need to be assessed individually for purpose of objectively value effectiveness and quality teachers' teaching activities. A survey was conducted among teachers and students in a college, where respondents were required to fill out and score the twenty-two evaluation indicators. The evaluation indicators range from 0 to 9, with each person completing one questionnaire. The resulting teaching quality questionnaire, shown in Table 2, includes twenty-one samples and evaluates certain sub-indicators while omitting others.

Table 2. Teachers' teaching quality questionnaire

Sample sequence number	Evaluation index (secondary index)							Evaluation objective (Y)
	X_1	(Teaching effect)	X_3	X_4	$X_5 \ldots X_{20}$	X_{21}	X_{22}	(Teaching effect)
1	6.5	5	7	4.5	……	6	7	7.75
2	4	9	5	6	……	7.5	6	6.5
3	6	6.5	8	4	……	7	6.5	6.5
4	7	6.5	7	6	……	7	7	7.25
5	8.5	4	9	5.5	……	8.5	8	8.5
6	6	7.5	6.5	7.5	……	7	7.5	7.25
7	7.5	4	8	6.5	……	6	7	8
8	6.5	5.5	6	7	……	7	7	6.25
9	7	3	6	5	……	5.5	6.5	6.75
10	8	5	9	5.5	……	7	7	7.5
11	7	6	8	7	……	6.5	7	6.75
12	6	8	7	7.5	……	6.5	7	7.5
13	6.5	6.5	6	5	……	6.5	6	6.75
14	7.5	8.5	5	7	……	8.5	7.5	6.75
15	6	9	5.5	6.5	……	6.5	5.5	6
16	6	9	5	7	……	5	6.5	6.5
17	7	5.5	6	5.5	……	7	7.5	7.5
18	4	7.5	3.5	5.5	……	4.5	6	6.25
19	4	8	6	5.5	……	6.5	6	6.5
20	5.5	4	4	3	……	4	6	6.75
21	9	6.5	8	6	……	6.5	8	8

Table 2 presents 22 secondary indexes that impact the teaching quality and effectiveness of teachers. However, since the teaching quality evaluation system encompasses qualitative factors, and the relationship between the input (twenty-two evaluation indicators) and the output (teaching effectiveness) is not necessarily linear, it is crucial to form a rational and systematic mathematical model. This model will help determine the mathematical relationship between the evaluation indexes and the evaluation objective (teaching effect). By employing a neural network system, we can create an objective and fair evaluation of teachers' teaching quality, which holds significant practical importance.

4 Teacher teaching quality evaluation based on neural network model

Neural network theory is a kind of information processing system with the style of human brain designed by simulating the way of human nervous system processing, memory and processing information on the basis of the research results of modern neuroscience[9-10]. Neural networks have the ability to learn from data samples and automatically approximate complex and nonlinear functions that describe the rules of the data. This makes them highly advantageous in miscellaneous applications including prediction, categorization, pattern identification, as well as operational management. By eliminating the need for tedious querying and expression processes, neural networks offer a more efficient and automated approach to learning from data. Compared with traditional data analysis and processing methods, it is more suitable to deal with fuzzy, nonlinear and ambiguous model characteristics.

4.1 Teacher teaching quality assessment neural network model and learning algorithm

The Backpropagation (BP) neural network is a type of artificial neural network that is widely used for supervised learning tasks. It consists of an input layer, one or more hidden layers, and an output layer. Each layer is composed of interconnected artificial neurons, also known as nodes. The BP neural network operates based on the principle of error backpropagation. During the training process, input data is fed forward through the network, and the output is compared to the desired output. The difference between the actual and desired output is used to calculate an error value. This error is then propagated back through the network, adjusting the weights of the connections between neurons to minimize the error. The BP neural network is capable of learning complex patterns and relationships in data, making it suitable for tasks like pattern recognition, classification, and prediction. Its ability to adapt and generalize from training data makes it a popular choice in various fields, including finance, healthcare, and image processing. In this study, a teacher teaching quality evaluation system is developed using the BP neural network. The system incorporates 22 secondary evaluation indicators as input and assesses the educational outcome as the output. The structure of the BP network is illustrated in Figure 1.

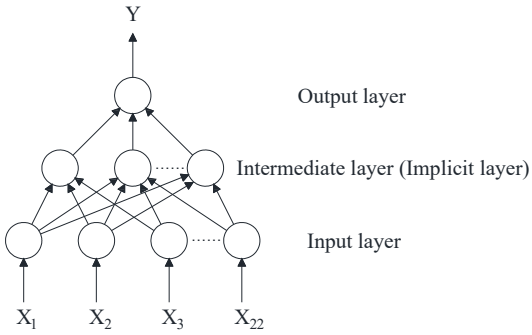

Fig. 1. Structure diagram of BP three-layer neural network

There is a weighting factor on the connection between each pair of neurons that strengthens or weakens the stimulation of the afterward neuron based on the export of the forward neuron. This weighting coefficient is usually called the weight value, and the rule for modifying the weight value is called the weight algorithm. Therefore, when the BP neural network is trained, a set of training samples must be provided first, and each sample consists of an input sample and an ideal output pair. When all the actual output of the network is consistent with the ideal output, the training is over. Otherwise, the ideal output of the network and the actual output can be matched by adjusting the weights, so as to minimize the mean square of error between the actual output value and the expected output value of the network. Therefore, the neural network model can be used to effectively identify the evaluation system of teachers' teaching and learning quality.

Set input layers as:

$$X = \{x(1), \ldots x(\mathrm{n})\} \tag{1}$$

Where X(1) to X(n) are the assessment indexs of teaching effectiveness assessment system.

The hidden layer can be set as:

$$net_i = \sum v_{ij} X \tag{2}$$

$$O_i = a(net_i) \tag{3}$$

Where $\{v_{ij}\}$ represents the Weight factor, and $a(x)$ indicates the activation function, the Sigmoid function is applied in this case:

$$\mathrm{a(x)} = \frac{1-e^{-\mathrm{x}}}{1+e^{\mathrm{x}}} \tag{4}$$

The output layer can be written as:

$$\hat{y} = \sum w_i O_i \tag{5}$$

Where $\hat{y}$ represents the Output response, $\{w_i\}$ represents the weight factor.

Set the objective function be：

$$E = \frac{[y-\hat{y}]^2}{2} = \frac{e^2}{2} \tag{6}$$

By minimizing the performance index, the BP algorithm guarantees the stability of the teaching quality assessment system. It utilizes the actual output y from the system as a feedback indicator and compares it with the predicted results $\hat{y}$ generated by the neural network system recognizer. This ensures that the error E is less than ε. In case the requirements are not met, the weight system undergoes continuous adjustments to meet the desired criteria.

4.2 Experimental simulation results and analysis

The teaching quality assessment system is recognized using a three-layer BP neural network. The number of nodes of the input, hidden, and output layers are 22, 44 and 1, respectively. The activation function used is sigmoid. The learning rate η is set to 0.9, and the learning training algorithm employed is the Backpropagation (BP) algorithm. As shown in Table 2, the data is taken as training sets for the neural network identification model with the error goal of 0.001. The simulation experiments was conducted, and the training process curve is obtained as illustrated in Figure 2. After reaching the desired training level, the identification values can be acquired shown in Table 3. From Table 3, it can be observed that the original data is extremely similar to the identification values and it indicates that the proposed BP network can accurately identify the teaching quality and effectiveness of the teachers based on various evaluation indicators.

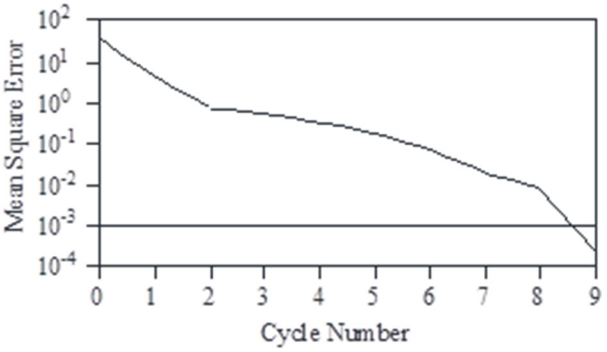

Fig. 2. Training process of BP neural network system

Table 3. The assessment and examination of identification values between the original data and the neural network system (NN) through comparison and analysis

Sample number	Evaluate goal	Identification value of NN	Sample number	Evaluate goal	Identification value of NN	Sample number	Evaluate goal	Identification value of NN
1	7.75	7.7487	8	6.25	6.2432	15	6	5.9994
2	6.5	6.4995	9	6.75	6.7487	16	6.5	6.4995
3	6.5	6.4991	10	7.5	7.4996	17	7.5	7.4991

4	7.25	7.2606	11	6.75	6.7504	18	6.5	6.2542
5	8.5	8.4988	12	7.5	7.4992	19	6.5	6.5012
6	7.25	7.2510	13	6.75	6.7514	20	6.75	6.7508
7	8	7.9989	14	6.75	6.7497	21	8	7.9984

5 Conclusion

(1) BP neural network has the potential to evaluate the teaching quality of university professors. By employing the BP algorithm, we can construct a three-layer neural network that accurately identifies the teaching quality and effectiveness of teachers by adjusting the weight system. This approach effectively analyzes teaching methods, student learning outcomes, and other relevant factors, providing a novel tool for teaching quality assessment.

(2) Using BP neural network for teaching quality evaluation can enhance objectivity and accuracy. Compared to traditional subjective evaluation methods, BP neural network can obtain a comprehensive assessment of a teacher's abilities through extensive data training. This objective evaluation method reduces subjective bias and personal preferences, resulting in more impartial and reliable assessment outcomes.

(3) The results of teaching quality evaluation using BP neural network can provide targeted feedback and improvement suggestions for teachers. By analyzing the output of the neural network, we can understand a teacher's performance in different aspects and offer corresponding advice and training. This helps teachers continuously improve their teaching methods and skills, enhancing teaching quality and promoting students' learning outcomes and satisfaction.

In conclusion, BP neural network has vast potential in evaluating the teaching quality of university professors. It improves objectivity and accuracy in assessment, provides targeted feedback and improvement suggestions for teachers, and further advances the quality of higher education.

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