Research of Students Learning Quality Evaluation System Based on BP Neural Network

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Abstract. The model of students' learning quality evaluation system is established based on BP neural network algorithm in this article. There are three level evaluation indexes and twelve secondary evaluation indexes through questionnaire method, it uses the AHP method to obtain all the weights of evaluation indexes, establishes the evaluation model based on the BP neural network, and after training and simulation then it gets the comprehensive evaluation results, finally gets the model. This article developed a virtual application platform and verified the model, then proved the correctness, objectivity and scientific of the model. For most universities and enterprises to develop the learning quality evaluation or the quality of staff work, it provides an important reference and has a certain reference value.

1. Introduction
Teaching quality evaluation plays an important role for teaching appraisal in colleges and universities, the appraisal objects mainly include teachers and students. For teachers' teaching quality evaluation system, which is based on the presupposition evaluation indexes, students score them, and through evaluation algorithm to obtain the final evaluation score for each teacher [1], the result can be used as one of the reference standard to judge teacher's teaching effect, and teachers can analyse the assessment results, further improve or enhance their teaching quality and teaching ability. For teachers' teaching quality evaluation, most of the colleges and universities are using them and the systems work very well at present. For the students' learning quality evaluation, there are no very sound comprehensive evaluation methods because of the complex influence factors [2]. The vast majority of colleges and universities still mainly adopt the way of exam-oriented education to evaluate students, namely through the students' learning achievement tests to evaluate students' learning quality, it has certain one-sidedness, contingency and fairness, etc., thus how to explore a new evaluation system to evaluate students' learning quality has very important value.

2. Establishing Indicators of Evaluation System
In order to get the indexes of students' learning quality evaluation system, this paper adopts the questionnaire to survey the teachers and students. The questionnaires have 121 copies, of which 57 copies are entity questionnaires, and the others are network questionnaires, recycles 117 copies, and 113 copies are valid. The data from statistical analysis show that it can get all the indexes of evaluation model for the three first-level indicators and twelve secondary indicators (see table 1).
Table 1. Indexes of students' learning quality evaluation

| first-level indicators | The serial number | secondary indicators | parameter |
|------------------------|-------------------|----------------------|-----------|
| Learning attitude      | 1                 | Preview situation    | $X_1$     |
|                        |                   | Review situation     | $X_2$     |
|                        |                   | Study on self-image  | $X_3$     |
|                        |                   | Multi-channel knowledge acquisition | $X_4$ |
|                        |                   | Knowledge exchange between classmates | $X_5$ |
| learning process       | 2                 | The teacher answer situation | $X_6$ |
|                        |                   | Homework completion  | $X_7$     |
|                        |                   | Class participation situation | $X_8$ |
|                        |                   | The final assessment result | $X_9$ |
| Learning effect        | 3                 | Participate in scientific research activities | $X_{10}$ |
|                        |                   | Scientific research awards | $X_{11}$ |
|                        |                   | Practice ability     | $X_{12}$ |

3. The application of AHP Method to Calculate Index Weight

Each secondary index corresponds to a parameter in the evaluation system, each parameter is according to the weight of each index in the evaluation system. This article uses the AHP (analytic hierarchy process) method to arrange the complex evaluation objects into an orderly recursive structure, then compares and judges between each evaluation index, and calculates the relative importance of each evaluating index, so as to gets the weights of all indicators [3].

3.1. Determine the Index Quantitative Standard

The core problem of AHP is to establish a reasonable and consistent construct judgment matrix, the rationality of the judgment matrix is affected by the rationality of the scale. The scale refers to the quantitative concept of importance level difference of each evaluating index. The methods of determining the importance of quantitative standard commonly are: proportional scale method and exponential scale method. Proportion scale method is based on criteria of the qualitative differences of things, general with five kinds of discriminant ranks that show the qualitative differences, when evaluation analysis needs higher accuracy, it can use nine kinds of discriminant levels to evaluate it. The meanings of various scale methods are shown in table 2.

Table 2. Proportion scaling method

| Meaning of Value                  | 1–9 scale | 5/5–9/1 scale | 9/9–9/1 scale |
|-----------------------------------|-----------|---------------|--------------|
| $i$ and $j$ are equally important | 1         | 1 (5/5)       | 1 (9/9)      |
| $i$ is little more important than $j$ | 3         | 1.5 (6/4)     | 1.286 (9/7)  |
| $i$ is more important than $j$    | 5         | 2.33 (7/3)    | 1.8 (9/5)    |
| $i$ is highly important than $j$  | 7         | 4 (8/2)       | 3 (9/3)      |
| $i$ is extremely important than $j$ | 9         | 9 (9/1)       | 9 (9/1)      |
| between the adjacent two levels of importance | 2,4,6,8 | 1.222 (5.5/4.5) | 1.125 (9/8) |
| $i$ and $j$ are equally important | 1         | 1 (5/5)       | 1 (9/9)      |
| $i$ is little more important than $j$ | 3         | 1.5 (6/4)     | 1.286 (9/7)  |
| $i$ is more important than $j$    | 5         | 2.33 (7/3)    | 1.8 (9/5)    |
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3.2. Establish the Initial Weights

The initial weights usually adopt the method of combining qualitative analysis with quantitative analysis. By organizing investigation group, this paper proposes the judgment of the data, and then forms the initial data based on the analysis and processing to the data [3].

The judging matrix is established, through AHP scale method and according to the initial evaluation results, a couple of judgment matrix is compared and obtains the judgment matrix, the judgment matrix in the \( i \) row and the \( j \) column represents index and the scale coefficient obtains after being compared respectively (see table 3).

| \( X_1 \) | 4 | 4 | 1.5 | 1/1.5 | 1/1.5 | 1/1.5 | 1.5 | 1/1.5 | 1 | 1.5 |
| \( X_2 \) | 1 | 1.5 | 1/1.5 | 1/2.33 | 1/4 | 1/2.33 | 1/4 | 1/1.5 | 1/4 | 1/4 | 1/2.33 |
| \( X_3 \) | 1/1.5 | 1 | 1/2.33 | 1/2.33 | 1/9.0 | 1/4.0 | 1/9.0 | 1/2.33 | 1/9.0 | 1/4.0 | 1/4.0 |
| \( X_4 \) | 1.5 | 2.33 | 1 | 1/1.5 | 1/2.33 | 1/1.5 | 1/2.33 | 1/2.33 | 1 | 1/2.33 | 1/1.5 | 1/1.5 |
| \( X_5 \) | 2.33 | 2.33 | 1.5 | 1 | 1/1.5 | 1.5 | 1/1.5 | 1/1.5 | 1/1.5 | 1/1.5 | 1 |
| \( X_6 \) | 4 | 9 | 2.33 | 1.5 | 1/1.5 | 1.5 | 1/1.5 | 1/4.0 | 2.33 | 1 | 1.5 | 1.5 |
| \( X_7 \) | 4 | 9 | 2.33 | 1.5 | 1 | 1.5 | 1/1.5 | 1/2.33 | 2.33 | 1.5 | 1.5 | 1.5 |
| \( X_8 \) | 2.33 | 4 | 1.5 | 1/1.5 | 1/1.5 | 1 | 1/1.5 | 1/1.5 | 1.5 | 1/1.5 | 1/1.5 | 1 |
| \( X_9 \) | 4 | 9 | 2.33 | 1.5 | 1.5 | 1.5 | 1 | 1/2.33 | 2.33 | 1.5 | 1.5 | 1.5 |
| \( X_{10} \) | 4 | 9 | 2.33 | 1.5 | 2.33 | 1.5 | 2.33 | 1 | 2.33 | 4 | 1.5 | 1.5 |
| \( X_{11} \) | 2.33 | 4 | 1.5 | 1/1.5 | 1/1.5 | 1/1.5 | 1/1.5 | 1/1.5 | 1.5 | 1/1.5 | 1/1.5 | 1 |
| \( X_{12} \) | 1.5 | 2.33 | 1 | 1/1.5 | 1/2.33 | 1/1.5 | 1/2.33 | 1/2.33 | 1 | 1/2.33 | 1/1.5 | 1/1.5 |

Through it calculates geometric average \( W_i \) of each scale data for every line of judgment matrix, then normalizes processing, namely uses the equation (as in equation 1) obtains the weight coefficient of each scale (see table 4).

\[
W'_i = \frac{W_i}{\sum W_i}
\]  

Table 4. Weight coefficient of twelve secondary indicators in evaluation system

| \( W_1 \) | 0.0591 | 0.1389 | 0.2051 | 0.0900 | 0.0715 | 0.0641 |
| \( W_2 \) | 0.0527 | 0.0765 | 0.0455 | 0.0272 | 0.0778 | 0.0909 |

4. The Determination of the Model

4.1. Initialization Process of Evaluation Data

The value of initial secondary index use the hundred percentage point system, while the range of the input data in the neural network is between 0 and 1, so first of all need to be normalization processing. At present, commonly the normalization functions are: exponential function method, the maximum and minimum method [4, 5], etc.. This article uses the maximum and minimum method to normalization processing the data, this method has characteristic which can better retains its original significance and is not easy to lose its information, etc., this method is a kind of linear transformation for data processing.

The input data evaluated by students adopts the equation (as in equation 2) of normalization processing.

\[
X = \frac{I - I_{\text{min}}}{I_{\text{max}} - I_{\text{min}}}
\]
By computing, the calculated results of twelve initialization evaluation data of secondary indicators are shown in table 5.

|   | X_1 | X_2 | X_3 | X_4 | X_5 | X_6 | X_7 | X_8 | X_9 | X_10 | X_11 | X_12 |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| 1 | 0.18| 0.69| 0.82| 0.27| 0.21| 0.19| 0.21| 0.38| 0.18| 0.08 | 0.31 | 0.36 |
| 2 | 0.06| 0.42| 0.62| 0.36| 0.21| 0.36| 0.21| 0.23| 0.38| 0.18 | 0.08 | 0.16 |
| 3 | 0.24| 0.28| 0.41| 0.36| 0.29| 0.36| 0.21| 0.23| 0.18| 0.08 | 0.42 | 0.27 |
| 4 | 0.31| 0.42| 0.82| 0.27| 0.21| 0.13| 0.16| 0.25| 0.14| 0.08 | 0.16 | 0.18 |
| 5 | 0.18| 0.28| 0.62| 0.36| 0.29| 0.36| 0.16| 0.25| 0.14| 0.11 | 0.31 | 0.27 |
| 6 | 0.06| 0.69| 0.62| 0.36| 0.29| 0.13| 0.16| 0.25| 0.18| 0.14 | 0.16 | 0.36 |
| 7 | 0.18| 0.69| 0.82| 0.36| 0.21| 0.26| 0.11| 0.25| 0.18| 0.11 | 0.31 | 0.36 |
| 8 | 0.24| 0.69| 0.82| 0.36| 0.21| 0.36| 0.21| 0.23| 0.18| 0.08 | 0.16 | 0.36 |
| 9 | 0.24| 0.42| 0.82| 0.36| 0.29| 0.26| 0.21| 0.31| 0.14| 0.08 | 0.31 | 0.27 |
| 10| 0.18| 0.69| 0.82| 0.36| 0.29| 0.36| 0.21| 0.31| 0.14| 0.08 | 0.31 | 0.36 |

4.2. The Number of Neurons in Each Layer

**The number of input layer neurons:** The input layer parameters of specific problems are used to determine the number of neurons in input layer. Evaluation model in this paper, the number of neurons in input layer is the number of secondary index, so the number of input layer is twelve.

**The number of output layer neurons:** The number of output layer neurons is decided by the evaluation results of the students' learning quality evaluation model. As a result, the output layer neuron number is being set to 1, and the specific meanings are shown in table 6.

| comprehensive evaluation | 90–100 | 80–89 | 70–79 | 60–69 | 59 and below |
|--------------------------|--------|-------|-------|-------|--------------|
| evaluation grade         | excellent | good | medium | poor | fail to pass |

**Hidden units number:** Reduce the hidden layer nodes can improve the adaptability of neural network to the new data, increase the generalization ability, and speed up the training. Therefore, on the premise of meet the learning accuracy, the hidden layer unit number h should be as small as possible. This article uses the "trial and error", that is, within the prescribed number of training, if there are a lot of didn't meet the convergence conditions or training times, then stop training. For three-layer neural network, the hidden layer unit number h can be obtained from equation (3). So the hidden layer unit number can be obtained for eight.

\[ h = \sqrt{n + m + a} \]  \hspace{1cm} (3)

4.3. The Preprocessing of the Input Data

Before the model input the data, the data need to be normalization processing. The input and output data are transformed for the interval [-1, 1], it can use the equations (as in equation 4 and equation 5).

\[ x_{mid} = \frac{x_{max} + x_{min}}{2} \]  \hspace{1cm} (4)

\[ x' = \frac{x_{i} - x_{mid}}{1/2(x_{max} - x_{min})} \]  \hspace{1cm} (5)
As in equation 4, after transformed by the above method, the maximum and the minimum converted to 1 and -1 respectively, and in the middle value of the original data is transformed to 0. When the input or output data are too dense, the data can be increase distance by above method.

5. Neural Network Training
The experiment is based on a large number of survey data, using the above modelling method to establish evaluation model. Adopting initial sample data to create network forecast model, and take repeated network training and simulation, and find the error in order to determine whether training goals are met. Neural network training process diagram is shown in figure 1. After simulated by neural network, the simulation diagram is shown in figure 2.

In figure 2, the symbol “+” shows the target result, symbol “O” shows model result, which can be clearly understand that the model of the neural network produced after the above training: the input validation data, the model output results and target output results contrast, and the compare results are shown in table 7.

| project | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   |
|---------|------|------|------|------|------|------|------|------|------|------|------|------|
| error   | 0.0158 | 0.0114 | 0.0121 | 0.0216 | 0.0171 | 0.0202 | 0.0130 | 0.0069 | 0.0162 | 0.0062 | 0.0069 | 0.0006 |

The above data shows that the training and prediction accuracy of students' learning quality evaluation model based on BP neural network are completely within the acceptable range, and it is a reasonable and feasible forecasting model.

Figure 1. Training process of neural network
6. Application Case
This project develops the online evaluation virtual platform of students’ learning quality based on SQL Server and ASP.NET. According to the established evaluation index, when the users (students or teachers) complete the learning quality evaluation tests and then submit, the system automatically generates a text file named evaluation.txt, and saves the evaluation results in disc, then imports them into MATLAB to calculate and analyse, and then the analysis and calculation results are dynamically imported into the platform for displaying the final evaluation grade (referred with figure 3). The result shows that this model is feasible which is used to evaluate students’ learning quality.

7. Summary
Based on the characteristics of the structure of the neural network, this paper puts forward the learning quality evaluation system through the BP neural network algorithm. Through modelling, it uses the MATLAB neural network toolbox to train and simulate the results of comprehensive evaluation. The simulation results show that the mathematical model has good ferreting precision and is suitable for
learning quality evaluation. Finally, it establishes the application operational platform and obtains the final evaluation results of some students. The experience shows that this model is feasible, and also makes the learning quality evaluation more objective, scientific and standardized.

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