Application of BP neural network on quantitative evaluation of curriculum reform in advanced education-A case study of signal and system

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Abstract. In this paper, BP neural network model is used to study and analyse the teaching reform of signal and system course. Referring to the structure of BP neural network, the quality evaluation index system of signal and system course is established. On this basis, the factors influencing students' examination results are predicted, and the questionnaire is designed and BP neural network is used for prediction. The mean square deviation of the result is 0.7788. Through the correlation coefficient analysis of the data obtained, we can get the major factors that affect students' final scores. In view of this, the paper puts forward the direction and specific measures of teaching reform of this course.

1. Introduction

With the rapid development of China's economy, the demand for clean energy is gradually increasing, and the rising nuclear industry is becoming the main factor to solve the problem. In this case, the demand for Nuclear related talents is also increasing. In response to the development of China's nuclear industry, some colleges have set up a national characteristic specialty which is nuclear specialty. In the teaching of this specialty, there are many courses involved and teaching methods are also very diverse. In order to ensure that the education career keeps pace with the times, the teaching reform is imminent. In 2018, Qiang Yang and others pointed out that the major covers a wide range of knowledge, the required experimental operations (involving radioactive sources and reactors, requiring larger experimental equipment) are complex and contain high risks. They proposed that the use of simulation software can not only avoid high-risk and high-cost problems, but also consolidate their knowledge [1]. In the same year, Xianli Zheng and others discussed the assessment methods of nuclear experiments. In order to arouse the enthusiasm of students and the fairness of the examination results, the proportion of experimental results comprehensively considered the students' practical ability, problem-solving ability, scientific attitude and habits, etc. It is concluded that the evaluation scheme of the experiment assessment is that the preview report and preview effect, the experimental process, the experimental operation examination and the evaluation of the experimental report account for 10%, 30%, 30% and 30% of the total score respectively [2]. In 2019, Yanfeng Peng and others based on VPMCD methods,
the variable prediction model was established to evaluate the teaching quality of university teachers in an all-round way. The indexes of students' evaluation of teaching, teachers' self-evaluation and peer-to-peer evaluation were used as input variables, and the results of teaching quality supervision and evaluation were taken as output variables. The experiment was repeated three times. The average error of the three results was less than 1.92%, and the number of wrong identification of evaluation grade was 0, that is to say, the recognition accuracy was evaluated 100%, which provides a new reference for teaching quality evaluation[3]. In 2015, Yong Zheng and others established a teaching quality evaluation model through BP neural network, set the convergence error bound value to 0.0001, and the training frequency less than 200 times can achieve sufficient accuracy, and the evaluation result obtained is consistent with the expert evaluation result [4].

In nuclear specialty, students need to analyze and process the collected nuclear signals, and the study of signal and system course is particularly important in this kind of specialty. Therefore, this paper will take the signal and system course as the research object, and analyze the teaching reform space and direction of the course based on the model established by BP neural network.

2. Algorithm
BP neural network is also called error back propagation neural network. The algorithm contains multi-layer neural network, which is connected by neurons, but the neurons do not affect each other horizontally. The structure includes: input layer, multi-layer hidden layer and output layer. The training process is divided into two stages: the first stage (forward propagation) input sample, selecting the ideal output value, and is calculating the corresponding actual output. Then, we go to the second stage (backward propagation), get the difference between the actual output and the ideal output, and then modify the connection weight layer by layer according to the way of minimizing the error, return the error to each node, adjust the threshold and weight of the node, adjust the weight matrix in the network, return to the input layer, calculate the error measure of the sample set, judge whether it is less than the minimum error and whether it is over the maximum iteration times, the results can be output if one condition is met. Otherwise, the initialization step will be returned and the cycle will be repeated. With the increase of the number of cycles, the accuracy will be improved. The parameters involved include: input vector, dimension of output vector, layer number of hidden layer and number of neurons in each hidden layer. The structure of BP neural network is shown in Figure 1:
Suppose there are $n$ samples in the input layer, then the input data vector and the output vector are:

$$x_n = (x_1, x_2 \ldots x_n), \quad n = 1, 2, \ldots n$$  \hspace{1cm} (1)

$$y_m = (y_1, y_2 \ldots y_m), \quad m = 1, 2, \ldots m$$  \hspace{1cm} (2)

For the network, the actual output is:

$$z_l = (z_1, z_2 \ldots z_l), \quad l = 1, 2, \ldots l$$  \hspace{1cm} (3)

Select the excitation function:

$$f(x) = \frac{1}{1+e^{-x}}$$  \hspace{1cm} (4)

If the weight matrix of input layer and hidden layer is marked as $W_{ik}$, then the calculation method of output value of node $K$ is:

$$y_k = f(\sum_{i=0}^{l} W_{ik} \ast X_i - B_K)$$  \hspace{1cm} (5)

Where $B_k$ is the threshold value, the error is minimized by modifying the weight $W_{ik}$, even if the sum of squares of the error is the smallest. The flow chart of BP neural network algorithm is shown below:
3. Experiment

3.1. Experimental design

The teaching of signal and system course is carried out with MATLAB software. Based on this, in order to analyze the current problems of the course, combined with 2018, the evaluation system of university teaching quality built by Fan Yan and others based on optimized BP neural network[5], and the teaching built by Yong Zheng and others in 2015 based on BP neural network in the teaching quality evaluation of university teachers[4]. A quality evaluation index system of signal and system course is established from four aspects: preview, classroom teaching, review after class and experimental learning (see Figure 3).
Figure 3. Quality evaluation index system of signal and system course.

From the established curriculum quality evaluation index system, we can see that the factors affecting the quality of the course include the students' understanding of the teaching objectives, the preview process, the teacher's lecture rhythm, the students' acceptance of the difficult and important points, the students' review after class, the exercises after class, and the students' experimental learning on experimental theory and operation. This paper makes the following prediction and analysis for the four parts that affect the quality of the curriculum:

In the teaching of a course, whether the test results meet the students' expectations is an important standard to measure the scientificity of the assessment system of the course, and also an important factor to investigate the teaching quality. Therefore, in the questionnaire survey for nuclear students, the design question is: whether the test results meet the expectations, and to represent the students' learning quality of the course.

In the preview before class, whether the students understand the teaching objectives of the course is helpful for them to make self-learning plans, grasp the key points of learning, and find out the missing points. At the same time, whether the students preview before class and finish the exercises before class will directly affect the class effect, so as to predict the impact on the final examination, and set questions: whether to understand the teaching objectives of the course, whether to preview the book content before class, and whether to complete the preview questions before class.

In the process of classroom teaching, the impact of teachers' pace of class on the classroom effect is related to the students' adaptability. Diversified teaching methods can help to improve students' enthusiasm in the classroom, and also can appropriately adjust the teachers' classroom rhythm, so as to bring students knowledge buffer time. The design questions are: do you think that the teacher's explanation speed is too fast, whether the classroom questioning is helpful to deepen the memory of knowledge points, whether the students' explanation in class is beneficial to improve the interest in class, and whether the discussion among students is more beneficial to the understanding of knowledge points.

About the review after class: in the learning of a course, the students' knowledge is mainly in the form of homework after class. Therefore, the relevance between the exercises and the class content reflected by the students reflects two problems: first, whether the exercises left by the teacher are reasonable and whether the proportion of the expanded content is too large; secondly, students' mastery
of the key content in the classroom. Whether it is accurate. Meanwhile, after class exercises are important reference objects for students' final review, and also one of the important factors that affect whether their final scores meet the expectations. Therefore, the following questions are set up: do you think the exercises after class are not closely related to the content of the class explanation, and whether to actively review after class.

In the experimental section of the course, students' mastery of experimental software will directly affect the effect of the experimental course, thus affecting the significance of the experimental course for students. The questions set up for this link are: whether you can skillfully use the experimental software, and whether you understand the content and significance of the experiment.

Based on the above questions, the questionnaire survey is designed, and a 5-point system (1 = completely inconsistent and 5 = fully conforming) is adopted for all the questions, so as to explore whether the above factors affect the quality of the course and the degree of influence. The questionnaire is distributed to the nuclear majors of Chengdu University of technology. The questionnaire is shown in Table 1.

| The serial number | Question |
|-------------------|----------|
| Q1                | Do you know the teaching objectives of this course |
| Q2                | Do you preview the book content before class |
| Q3                | Do you complete the preview questions before class |
| Q4                | Do you think the teacher's explanation speed is too fast |
| Q5                | Do you think classroom questioning is helpful to deepen the memory of knowledge points |
| Q6                | Do you think the students' explanation in class is beneficial to improve students' interest in class |
| Q7                | Do you think it is beneficial to understand the knowledge points by discussing with each other |
| Q8                | Do you think there is little relevance between the exercises after class and the contents explained in class |
| Q9                | Do you take the initiative to review after class |
| Q10               | Do you skillfully use the experimental software |
| Q11               | Do you understand the content and significance of the experiment |
| Q12               | Are the test results in line with expectations |

3.2. Experimental results and discussion

For 84 questionnaires sent out, 84 questionnaires were collected, 18 extreme questionnaires were excluded, and 66 valid questionnaires were obtained. Take the data from Q2: Are the test results in line with expectations as the output variable, and the data from Q1 to Q11 as the input variables of BP neural network. Taking 55 questionnaires as the training set, when building the model, three-layer and four-layer BP neural network were built respectively. It was found that the four-layer BP neural network was more stable. This layer was selected to analyze the data, and the number of training was 600 to get the relationship between input variables and output variables. Then the remaining 11 questionnaires were used as test set. The predicted results are shown in Table 2.
Table 2. The comparison of predicted value with the real value in the 11 questionnaires.

| Serial number | Real value | Predicted Value | The correlation coefficient | P value | Mean square error |
|---------------|------------|-----------------|----------------------------|--------|------------------|
| 1             | 2          | 2.095           |                            |        |                  |
| 2             | 5          | 3.804           |                            |        |                  |
| 3             | 2          | 2.545           |                            |        |                  |
| 4             | 5          | 3.024           |                            |        |                  |
| 5             | 3          | 3.678           |                            |        |                  |
| 6             | 4          | 3.027           | 0.728                      | 0.011  | 0.7788           |
| 7             | 3          | 2.678           |                            |        |                  |
| 8             | 5          | 3.126           |                            |        |                  |
| 9             | 5          | 3.804           |                            |        |                  |
| 10            | 3          | 2.875           |                            |        |                  |
| 11            | 5          | 3.648           |                            |        |                  |

Compare the predicted value with the real value, see Figure 4.

![Figure 4. Comparison between 11 groups of predicted data and real data.](image)

It can be seen from Table 3 that the correlation coefficient value between the predicted value and the real value is 0.728, and shows a significant level of 0.05, which indicates that there is a significant positive correlation between the predicted value and the real value. It can be seen intuitively in Figure 4 that most of the predicted data are not significantly different from the true value, among which the group 4, 8 and 11 have large differences, but the overall mean square deviation is not more than 0.7788, which shows that the model established by BP neural network is feasible for predicting the teaching quality results.

However, for the large deviation in the forecast data, the reasons are summarized as follows: the designed questionnaire is not comprehensive enough, and the table data cannot fully reflect the real situation of students. The evaluation system of teachers' teaching quality still needs to be improved to
make it more scientific. The evaluation object is only students, which is too single. Students' evaluation of curriculum is easily affected by teachers' status and qualifications. Therefore, it should diversify the survey objects.

Then the correlation between 11 input variables and output variables is analyzed, and the results are shown in the Figure 5.

![Figure 5. Correlation coefficient between influencing factors and output variables.](image)

The P value and correlation coefficient of each influencing factor are shown in the Table 3.

| Related factors                          | Correlation coefficient | P value |
|-----------------------------------------|-------------------------|---------|
| 1 Teaching objectives                   | 0.647**                 | 0.000   |
| 2 Preview book content                  | 0.491**                 | 0.000   |
| 3 Preview questions before class        | 0.617**                 | 0.000   |
| 4 The speed of classroom explanation is too fast | -0.682**               | 0.000   |
| 5 Classroom questioning                 | 0.271                   | 0.057   |
| 6 Classroom presentation                | 0.452**                 | 0.001   |
| 7 Discussion among students             | 0.462**                 | 0.001   |
| 8 Exercises after class                | -0.261                  | 0.067   |
| 9 Active review after class             | 0.623**                 | 0.000   |
| 10 Using experimental software          | 0.568**                 | 0.000   |
| 11 Content and significance of the experiment | 0.555**                 | 0.000   |

* p<0.05  ** p<0.01

The correlation diagram between the influencing factors with P value < 0.05 and the output variables was made, as shown in Figure 6.
Figure 6. Correlation between influencing factors of P value < 0.05 and output value.

Generally, it can be obtained that:

1. The P value of teachers' questions in class, the relevance between exercises and classroom content and teaching quality is more than 0.05, which means that there is no correlation between teachers' questions and test results, which is quite different from the results of the initial analysis.

2. The speed of teacher's explanation in the final examination is negatively related to the quality of classroom teaching.

3. The correlation between other factors and final scores is positive, that is to say, it can increase the proportion of these factors in the course to improve the students' final examination level. It can be seen from Figure 5 that among the positive correlation factors, Q1, Q3 and Q9 have the largest correlation coefficients, which are 0.617, 0.647 and 0.623, respectively. That is, whether the students understand the teaching objectives of the course, complete the preview before class, and actively review after class have a greater impact on the final score of students.

Based on the above data analysis, the following teaching reform suggestions can be made:

At the beginning of teaching, the teacher clearly emphasizes the teaching objectives of this course. It is suggested that students should make corresponding learning and review plans according to the teaching syllabus according to their own situation. Before the course is launched, they should estimate their own shortcomings in the course and supplement relevant knowledge in advance.

The proportion of the completion of the preview questions before class into the final examination scores is increased, so as to improve the students' attention to the preview link. In the preview questions, more basic concept knowledge understanding and mastering questions are designed to enable students to complete the study of conceptual knowledge in the time after class. In the classroom, teachers can spend most of their time on explaining the important and difficult points. And it can reduce the speed of teaching and help students grasp the important and difficult knowledge.

The correlation coefficient between whether students actively review after class and final grade is 0.623, ranking the third in terms of the impact on the score. However, to urge students to actively review after class can be carried out in combination with network teaching platform (such as MOOC, Superstar Learning Link, etc.), and teachers can publish relevant knowledge points on the platform, which is interspersed with exercises, and the completion of exercises can be appropriately added to final examination results. At the same time, students' interest groups can be set up in the final examination
results, and those who actively answer questions in the group can increase their usual scores in class, so as to mobilize students' enthusiasm for review after class.

However, the correlation between the exercises and the contents of the class explanation has little effect on the final scores of students. Therefore, teachers can design the homework after class in a diversified way and add appropriate knowledge to expand the students' enthusiasm for the course, which has a similar effect on the related courses.

4. Conclusions
There are many factors that affect students' final exam results, which can be divided into preparation for class, teacher's explanation, students' review after class and experimental learning. BP neural network is used to predict students' test results. The mean square deviation of the results is less than 0.7788, which provides an effective way to predict students' scores. It is concluded that the factors that have great influence on students are mainly distributed in the preview and review after class, while the most influential factor in the classroom is the speed of teachers' explanation. Therefore, in the teaching reform of this course, we can focus on the direction of students' preview before class, and focus on improving students' enthusiasm for review after class. By adjusting the proportion of explanation time of knowledge points in class, teachers can reduce the teaching speed and diversify the proportion of final scores, which is conducive to the achievement of students' expected examination results.

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