Empirical Research on Evaluation system of College Mathematics Teaching Quality Based on BP Neural Network

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Abstract

Mathematics is the important and difficult points in college teaching and how to improve mathematics teaching quality is key issue of college teaching research always. Under the background of highly informationzed education, various emerging teaching modes spring up, however, college mathematics teaching still mainly uses traditional classroom teaching and this teaching level directly decides teaching level of higher mathematics. Teaching quality evaluation is an important means of teaching quality and achievements within a period of time and mathematics teachers can know problems and shortcomings in teaching work according to education quality evaluation results and seek settlement specifically, which is of great importance to improving mathematics teaching. Therefore, this paper built the evaluation system of college mathematics teaching quality based on BP neural network and carried out effective quality evaluation of college teaching work, used as reference for improvement of college mathematics teaching level.

Keywords: BP Neural Network, College Mathematics, Teaching Quality Evaluation System.

1. RESEARCH OVERVIEW

1.1 Research Background

Under the background of educational informationization and globalization, college teaching environment had a huge change, reflected in teaching thought and way as well as higher education system. The scale of higher education in China is expanding from 1999 and college students in our country have ranked first in the world so far. However, rapid development of higher education also reveals a range of issues of China’s higher education system, for example, insufficient teachers in universities and colleges, high teaching pressure of teachers, quality reduction of student source, and the talents cultivated cannot meet the needs of social development usually. All sectors of society pay considerable attention to these issues and increasingly emphasize college teaching quality. Hence, how to improve teaching quality became the research focus of colleges and universities. Mathematics is the important and difficult points in college teaching because of deeply abstraction and theoretical property and there is higher requirement for teaching quality evaluation. So, it is necessary to build the evaluation system of college mathematics teaching quality based on BP neural network to improve the teaching quality evaluation level and it is of great significance for promotion of college mathematics teaching level.

1.2 Literature Review

With the reform and development of China’s education system, higher education changes to mass education from elite education and is going to be democratized, meaning that higher education in China has stepped into a new stage of development. Our country certainly becomes a powerful human resources country from big human resources country and puts more focus on cultivation of high-quality professionals and overall promotes the improvement of education quality. How to improve the teaching quality becomes major concern of colleges and universities (Wang et al., 2012). Teaching quality evaluation mainly plays the following roles in college mathematics teaching: diagnostic function, helping teachers to summarize teaching experience and lessons; feedback function, providing scientific feedback to mathematics teaching; incentive function, initiating teachers’ teaching enthusiasm through horizontal comparison; leading function, promoting scientific development of teaching and decision; management function, giving intuitive proof of college human resources and performance management (Dong et al., 2016). Artificial neural network, rose in the 1980s, is an important branch of artificial
intelligence that simulates cerebral neurons and builds models. BP neural network is an artificial neural network and widely applied form as well. BP neural network can classify any complex problem model, has mapping ability of multi-dimension function and can effectively solve problems that traditional artificial neural network sensor cannot. It includes three layers, namely, input layer, hidden layer and output layer and plays an important role in the evaluation of college mathematics teaching quality (Su and Wei, 2011).

2. EVALUATION MODEL OF COLLEGE MATHEMATICS TEACHING QUALITY BASED ON BP NEURAL NETWORK

2.1 Adaptability of BP Neural Network in College Mathematics Teaching Quality Evaluation

In recent years, the evaluation of college teaching quality has received considerable attention of all sectors of society and Ministry of Education carries out unified teaching quality evaluation of colleges and universities every year. However, the teaching quality is affected by many factors and most factors cannot be expressed by quantized data, causing the difficulty of expression of college mathematics teaching quality by mathematical formula or analytic expression. Hence, it is rather difficult to evaluate college mathematics teaching quality. Other evaluation methods, such as fuzzy comprehensive evaluation and analytic hierarchy process, may cause certain deviation as well because of certain subjectivity (Fang and Xiao, 2011). But with the development of artificial neural network, BP neural network shows apparent advantage in evaluation of college mathematics teaching quality and can find out rules in massive amount of teaching data through continuous learning, which cannot be realized by any traditional quality evaluation methods. Therefore, evaluation system of college mathematics teaching quality based on BP neural network can effectively solve qualitative and quantitative indexes in quality evaluation and calculate the mathematical models and analytic expressions in traditional evaluation mode more efficiently, and get more accurate results because BP neural network carries out the calculation and can effectively avoid human's subjectivity to affect the conclusion (Zhang, 2011).

2.2 Evaluation Model of College Mathematics Teaching Quality Based on Bp Neural Network

Figure 1 shows the evaluation model of college mathematics teaching quality based on BP neural network

![Figure 1. Evaluation Model of College Mathematics Teaching Quality Based on BP Neural Network](image)

Evaluation model of college mathematics teaching quality based on BP neural network includes eight subsystems, the first subsystem is mutual evaluation of teachers, namely, teachers mutually evaluate teaching ability and enthusiasm; the second subsystem is supervision and evaluation, namely, supervise and evaluate teachers’ teaching ability through daily inspection and random inspection; the third subsystem is student evaluation of teaching, namely, students evaluate the teaching method and level of teachers through classroom learning; the fourth subsystem is self-assessment of teachers, namely, teachers analyze their own teaching level according to self-evaluation; the fifth subsystem is student peer review, namely, students evaluate their learning ability mutually to feed back teachers’ teaching level; the sixth subsystem is the supervision and evaluation, namely, the supervisor
evaluates the learning level of students through analysis of corresponding data and inspection; the seventh subsystem is teacher evaluation, namely, teachers analyze the learning level of students according to classroom teaching; the eighth subsystem is self-assessment of students, namely, students analyze their learning level according to a period of study (Tang, 2016).

Figure 1 shows that evaluation model of college mathematics teaching quality based on BP neural network can be divided into two layers of frame. The first layer is subsystem neural network, which mainly uses three-layer BP neural network models and each layer of neurons only connects with adjacent layer of neurons and the neurons of the same layer do not connect with each other; data input into subsystems is secondary index, and after input of mass data into subsystems, BP neural network can carry out continuous adjustment and optimization of subsystems after its autonomous learning and make final conclusion (Guo, 2015). The second layer is integrative neural network and its network models are similar to those of subsystems, and input values of integrative neural network are output values of subsystems, and final evaluation result can be obtained as shown in Table 1 according to five grades of output value:

<table>
<thead>
<tr>
<th>Grade standard</th>
<th>Output value of neural network</th>
</tr>
</thead>
<tbody>
<tr>
<td>excellent</td>
<td>1.00–0.90</td>
</tr>
<tr>
<td>good</td>
<td>0.89–0.80</td>
</tr>
<tr>
<td>secondary</td>
<td>0.79–0.70</td>
</tr>
<tr>
<td>pass</td>
<td>0.69–0.60</td>
</tr>
<tr>
<td>Fail</td>
<td>0.60 Following</td>
</tr>
</tbody>
</table>

Integrative neural network mainly includes five standards: score > 0.90: excellent, 0.89–0.90: good, 0.79–0.70: intermediate, 0.69–0.60: passed, < 0.59: failed (Zhao, 2011).

2.3 Empirical Research on Evaluation of College Mathematics Teaching Quality Based on Bp Neural Network

According to aforesaid analysis, evaluation system of college mathematics teaching quality based on BP neural network mainly consists of a three-layer BP neural network, of which, input layer (Figure 1) has eight values while output layer has only one output value with the range of [0,1]. Empirical research shall be carried out after evaluation model of college mathematics teaching quality based on BP neural network is built to validate this model (Cai and Cao, 2011).

2.3.1 Construction of Quality Evaluation Index System of Mathematics Teaching in Colleges and Universities

<table>
<thead>
<tr>
<th>First level index</th>
<th>Two level index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching attitude</td>
<td></td>
</tr>
<tr>
<td>X1</td>
<td>Correct teaching attitude</td>
</tr>
<tr>
<td>X2</td>
<td>Take care of students</td>
</tr>
<tr>
<td>X3</td>
<td>Rigorous scholarship</td>
</tr>
<tr>
<td>Content of courses</td>
<td></td>
</tr>
<tr>
<td>X4</td>
<td>Target prominent</td>
</tr>
<tr>
<td>X5</td>
<td>Language accuracy</td>
</tr>
<tr>
<td>X6</td>
<td>Combining theory with practice</td>
</tr>
<tr>
<td>teaching method</td>
<td></td>
</tr>
<tr>
<td>X7</td>
<td>High professional level</td>
</tr>
<tr>
<td>X8</td>
<td>Keep up with the syllabus</td>
</tr>
<tr>
<td>X9</td>
<td>The classroom atmosphere is warm</td>
</tr>
<tr>
<td>teaching effectiveness</td>
<td></td>
</tr>
<tr>
<td>X10</td>
<td>Students have improved their practical level</td>
</tr>
<tr>
<td>X11</td>
<td>The students have improved their self-study level</td>
</tr>
<tr>
<td>X12</td>
<td>Students solve practical problems</td>
</tr>
</tbody>
</table>
Evaluation system of higher mathematics teaching quality mainly includes four parts:

Teaching attitude, mainly including three points, firstly, whether teachers observe law and discipline, arrive late and leave early, are absent or switch classes; secondly, whether teachers care for students, communicate with students and really care about students’ development; thirdly, whether teachers are rigorous in teaching, prepare lessons and correct students’ homework carefully and answer questions properly, and whether teachers prepare teaching aids such as teaching courseware adequately (Zhang, 2014).

Teaching contents, mainly including three points, firstly, whether the teaching objective is clear and highlighted, whether teaching activities can be carried out specific to certain teaching objective, and whether to select proper teaching contents and difficulty according to student’s learning condition, and realize individualized teaching. Secondly, whether the language is accurate and concise and reflects the teaching center. Meanwhile, check the teachers’ application of information technology under the background of educational informationization. Thirdly, ensure that students can combine theory with practice and develop students’ creative thinking ability and comprehensive quality as develop their mathematics learning ability (Zhao et al., 2015).

Teaching methods, mainly including three points, firstly, whether teachers have high professional knowledge and can put mathematical knowledge into practice. Secondly, whether teachers can select proper teaching methods according to actual teaching situation, which is consistent with overall direction of teaching program. Thirdly, whether the classroom atmosphere is animated and effectively arouses students' learning initiative and whether students can overall stimulate the relation between themselves and the society.

Teaching effects, mainly including three points, firstly, whether students’ specialized theoretical knowledge is perfect after a period of mathematics teaching and whether they can combine the theory with market price; secondly, whether students have improved their after-class autonomous learning and innovation abilities after and during a period of mathematics learning; thirdly, whether teachers can emphatically cultivate the high-quality talents needed by the society after a period of mathematics teaching; a perfect information education management system can be built specific to results obtained through quality evaluation index system of college mathematics teaching and is of great importance to promoting college mathematics teaching quality and students' comprehensive quality (Ji et al., 2017).

2.3.2 Structural Design of Bp Neural Network Model

Firstly, build a complete BP neural network framework and confirm input values, i.e., number of input nodes, number of output nodes, number of hidden layers and number of nodes per layer, then adjust overall BP neural network structure according to contents obtained above and make initial import parameters and BP neural network starts autonomous learning. During training process, if BP neural network presents stable learning state and result error is acceptable or iterative training times reach preset standard, BP neural network can calculate college mathematics teaching quality with better accuracy (Zhang and Hong, 2016). Specific procedures are as follows:

(1) Confirmation of input layer nodes

According to aforesaid contents, evaluation indexes of college mathematics teaching quality mainly include teaching attitude, contents, methods and effects, which are primary indexes. Meanwhile four primary indexes include twelve secondary indexes and these secondary indexes are the nodes of input layer of BP neural network.

(2) Confirmation of output layer nodes

To evaluate college mathematics teaching quality, design four evaluation results, namely, excellent, good, intermediate, passed and failed, which mainly depends on output value. BP neural network has only one output layer node and its value range is within [0, 1].

(3) Confirmation of hidden layer nodes

Key and difficult points in the evaluation of evaluation of college mathematics teaching quality based on BP neural network are the confirmation of hidden layer nodes and it is still not solved now. Theoretically speaking, too few hidden layer nodes will slow down total calculation speed and too many hidden layer nodes will cause too complex topological structure, greatly lengthening training time and bringing certain error. Nowadays, cut-and-try method
is the best way to confirm hidden layer nodes and its main formulas are as follows:

\[ m = \sqrt{n + 1 + a} \]  
(1)

\[ m = \log_2 n \]  
(2)

\[ m = \sqrt{nl} \]  
(3)

Where, \( m \) represents hidden layer nodes; \( n \) represents input layer nodes; \( l \) represents output layer nodes; \( a \) is a constant, with value range of \([1, 10]\). According to above formula, if hidden layer nodes are preset, the calculation shows that the optimal number is 7 nodes (Zhao, 2013).

(4) Confirmation of activation function

Activation function is an important part of neural network and this network mainly adopts tansig hyperbolic tangent function. In this experiment, the value range of output layer is \([0, 1]\), so activation function of this layer is Sigmoid function and its formula is as follows:

\[ f(x) = \frac{1}{1 + e^{-x}} \]  
(4)

(5) Construction of BP neural network model

Figure 2 shows the BP neural network model of students’ teaching evaluation system:

![BP Neural Network Model of Student Evaluation of Teaching](image)

It includes 12 input layers, 7 hidden layers and 1 output layer and output values of hidden layer node \( h \) and output layer node \( s \) can be expressed by the following formulas:

\[ y^h_k = f(\sum_{i=1}^{12} w_{ih} x^k_i + \theta_h) \]  
(5)

\[ o^s_k = g(\sum_{h=1}^7 w_{hh} y^h_k + \theta) \]  
(6)

(6) Selection of autonomous learning algorithm of BP neural network

Traditional autonomous learning algorithm of BP neural network mainly adopts gradient descent method and its core idea is building an error function during autonomous training process and reducing the output value of this function through continuous training until reducing to zero. But, this method has some drawbacks, such as local minimum, so the gradient descent method should be improved. LMBP optimization algorithm is a product after improvement of traditional method, with higher efficiency and accuracy, and can better evaluate the college mathematics teaching quality via BP neural network. Its core idea is providing certain opportunity of increasing error space rather than development in one direction during every updating and iteration of knowledge system, and this method can effectively improve the learning and calculation efficiency and still having superior effect through continuous selection (Ren et al., 2016).
REFERENCES

Tang G.H. (2016). Preliminary study on the evaluation of learning quality of college students in Mathematics Department, Liaoning higher education research, (1), 114-120.