Hindawi
Wireless Communications and Mobile Computing
Volume 2022, Article ID 3539912, 9 pages
https://doi.org/10.1155/2022/3539912

Research Article

Evaluation Model of Mathematics Teaching Quality Based on Recurrent Neural Network

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Received 21 April 2022; Revised 16 May 2022; Accepted 27 May 2022; Published 10 June 2022

Academic Editor: Zhiguo Qu

This study proposed an evaluation model of mathematics teaching quality under recurrent neural network for the sake of making the evaluation model of mathematics teaching quality have good fault tolerance. This model decomposes the initial data sequence of mathematics teaching quality evaluation into high- and low-frequency sequence by wavelet analysis and reconstructs it by using phase space. After introducing the recurrent neural network model, the data is reconstructed after model training, and the data mining is carried out for the evaluation of mathematics teaching quality. In the process of constructing the evaluation model, the evaluation index system should be constructed based on three dimensions firstly, and the evaluation index of association rules should be defined, so as to realize deep dig of data and obtain the phase space distribution of data and then carry out the constraint test of parameters to evaluate the mathematics teaching quality scientifically and accurately. After verification, it is known that the average values of training error and test error of the model proposed in this paper are 3.02% and 2.61%, and the average values of absolute error and relative error are 0.58 and 3.82%. This model can retain the valid data information in the initial sequence, and the evaluation results of mathematics teaching quality are relatively ideal, which greatly improves the efficiency and level of mathematics teaching.

1. Introduction

As an important part of college mathematics teaching, the evaluation of mathematics teaching quality can reflect the teaching effect more truly and comprehensively and plays an important role in adjusting the teaching plan and carrying out the teaching work better. Evaluation of college mathematics teaching quality refers to the process of observing the teaching process of mathematics teachers and making value judgment according to certain standards [1–3]. The results of teaching quality evaluation will be an important basis for the evaluated to improve their skills and the decision-making of relevant departments. At present, all colleges have fully realized the importance of carrying out teaching quality evaluation and put it in the first place of teaching management [4]. Qualitative rating method [5], quantitative evaluation method [6], and combination of qualitative evaluation and quantitative evaluation method are three kinds of teaching quality evaluation methods that are widely used at present [7]. These evaluation methods have their own unique evaluation advantages and application scope, but in the detailed application process, the optimal evaluation methods should also be selected in combination with the actual evaluation needs and evaluation purposes. Reference [8] designs the quality evaluation model of mathematics teaching mode reform in colleges and universities by using genetic algorithm and optimizes the evaluation effect of the completion of comprehensive objectives based on the principle of simulated annealing algorithm, which can ensure the accuracy and effectiveness of the evaluation results. Reference [9] analyzes the application of fuzzy mathematics and machine learning algorithm in the evaluation model of educational quality. The experiment results show that this model realizes the scientific and comprehensive evaluation of mathematics teaching quality. Reference [10] constructs the quality record model of English test preparation based on the decision tree and uses the conjugate decision limit working process to promote the extraction of data reflecting the quality attributes of English education, so as to realize the quality evaluation method of English test preparation.

However, the above methods are easily disturbed by the external environment in the process of practical application, resulting in low accuracy and poor efficiency of the evaluation results. In order to solve these problems, based on the data mining of mathematics teaching quality evaluation based on recurrent neural network, this paper uses the big data analysis method to construct the mathematics teaching quality evaluation model, realize the scientific evaluation of mathematics teaching quality, optimize the teaching mode, and improve the teaching effect based on the evaluation results.

2. Data Mining of Evaluation of Mathematics Teaching Quality under Recurrent Neural Network

2.1. Data Sequence Reconstruction of Evaluation of Mathematics Teaching Quality by Wavelet Analysis

2.1.1. Wavelet Analysis Principle. Wavelet analysis is mainly used to analyze time-frequency signals [11, 12]. It is a function that can attenuate to 0 in the shortest time, with existence and oscillation. The description formula is

$$U_{a,b}(t) = |a| U\left(\frac{t-b}{a}\right), \tag{1}$$

where $U_{a,b}(t)$ and $U(\cdot)$ represent subwavelets and base wavelets, respectively, and a and b represent scale and time factors, respectively.

If $U_{a,b}(t)$ can satisfy formula (1), the wavelet variation formula of energy limited signal $f(t)$ is

$$f(t) = |a| \bar{U}\left(\frac{t-b}{a}\right), \tag{2}$$

where $\bar{U}(t)$ represents complex conjugate function. Formula (2) verifies that wavelet transform can decompose signals according to different scales, which is equivalent to filtering signals with different filters.

Suppose $f(i\Delta t)$ is a discrete signal, where Δt represents the sampling interval. When $\{i = 1, 2, \cdots, n\}$, the discrete expression formula of formula (2) is

$$f'(t) = |a| \sum_{i=1}^{n} f(i\Delta t) \bar{U}\left(\frac{i\Delta t - b}{a}\right). \tag{3}$$

According to the discrete calculation formula, the signal decomposition and reconstruction can be realized.

2.1.2. Decomposition and Reconstruction of Data Series for Mathematics Teaching Quality Evaluation. Assuming that $\{x(t)\}$ represents the data sequence of mathematics teaching quality evaluation, the decomposition algorithm is

$$D_i(t) = \sum_{k=1}^{n} h(k) x_{i-1}(t+k), \tag{4}$$

where $h(k)$ represents the discrete low-pass function in the filter.

The analysis of discrete wavelet is used to identify all sequence features. The initial sequence of reconstructed mathematics teaching quality evaluation data is

$$x(t) = D_i(t) + \sum_{i=1}^{n} f(i\Delta t). \tag{5}$$

According to the calculation result of formula (5), the decomposition and reconstruction of mathematics teaching quality evaluation data are realized.

2.2. Data Mining Method for Mathematics Teaching Quality Evaluation. As a kind of neural network, the connections between nodes in recurrent neural network constitute a directed graph along the practice sequence, which has time dynamic behavior [13]. Its core is a directed graph, which contains chained elements. According to the principle and characteristics of recurrent neural network, the evaluation model of college mathematics teaching quality is constructed. Through in-depth mining of data, the evaluation work can be implemented more effectively, and the evaluation data can be more scientific and comprehensive, so that the evaluation efficiency of final teaching quality is improved.

2.2.1. Principle of Recurrent Neural Network. The self-feedback neuron is substituted into the recurrent neural network (RNN) [14, 15], which enables the RNN to generate the function of memory data, so as to mine the correlation characteristics of samples through the correlation detection of existing time series and current time series.

The sequence structure diagram of the recurrent neural network is shown below.

In Figure 1, the duration state points of RNN training are $t, t-1, t+1$, respectively, and the input vector at time t is X_t, the hidden layer vector is h_t, and the output vector is Y_t. The three vectors connect and share each other's weights at different times, which can effectively reduce the amount of RNN parameters.

The output value X_t neuron and the hidden layer neuron at time $t-1$ jointly determine the current hidden layer value h_t, that is,

$$h_t = g(wX_t + wh_{t-1} + c), \tag{6}$$

where $g(\cdot)$ represents the activation function, the bias vector is represented by c, and the timing weight of recurrent neural network is represented by w.

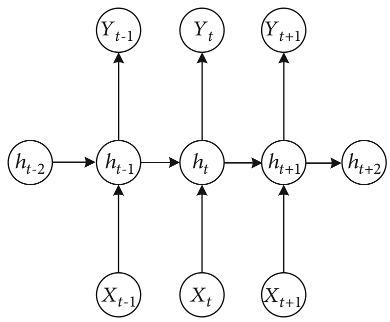


Figure 1: Schematic diagram of RNN timing structure.

Select the rectifier linear unit activation function [16], namely,

$$g(\cdot) = \begin{cases} 0, x \leq 0, \\ x, x > 0. \end{cases} \quad (7)$$

The feature vector is transformed into category probability distribution by softmax function [17, 18]; then,

$$Y_t = Ph_t g(wX_t + wh_{t-1} + c), \quad (8)$$

where P represents the output probability, which is greater than 0 and less than 1. According to the output value of category probability distribution, generate cyberspace and complete high-quality and high-precision data mining.

2.2.2. Construction of Data Mining Model for Data Teaching Quality Evaluation. Through wavelet analysis, decompose and reconstruct the initial sequence of preprocessed mathematics teaching quality evaluation data, obtain the different high- and low-frequency sequences, reconstruct the network phase space with the new sequence, use the newly generated data for the training data of recurrent neural network, and construct the data mining model of evaluation of mathematics teaching quality. The model structure is shown in Figure 2.

The specific steps of building the model shown in Figure 2 are as follows.

Step 1. Standardize and unify the past data information of mathematics teaching quality evaluation in colleges and save the minimum and maximum values.

Step 2. Carry out wavelet decomposition for the average annual mathematics teaching quality evaluation sequence, and carry out single branch reconstruction according to the decomposition size [19], so as to obtain the coefficients of the reconstructed sequence, reconstruct the repeated branching coefficients, and form high- and low-frequency sequences finally. Among them, the high-frequency sequence saves information, and the low-frequency sequence describes the change trend of the initial sequence of mathematics teaching quality evaluation data.

Step 3. Set the reconstructed delay value, reconstruct the high- and low-frequency sequences, and generate data information related to evaluation of mathematics teaching quality.

In the process of constructing the data mining model, when using the initial evaluation data sequence $\{x(t)\}$, the phase space reconstruction processing is adopted first, and the sequence is transformed into a matrix into $n_{\text{in}} \times m_{re}$, where n_{in} represents the data latitude and m_{re} represents the sample value, and then, the matrix structure is

$$X = \begin{bmatrix} x_1 x_2 \cdots x_{n_{\text{in}}} \\ x_2 x_2 \cdots x_{n_{\text{in}}+1} \\ \vdots \vdots \cdots \vdots \\ x_{m_{re}} x_{m_{re}+1} \cdots x_{n_{\text{in}}+m_{re}-1} \end{bmatrix}, \quad (9)$$

$$Y = \begin{bmatrix} y_{n_{\text{in}}+1} \\ y_{n_{\text{in}}+2} \\ \vdots \\ y_{n_{\text{in}}+m_{re}} \end{bmatrix}. \quad (10)$$

Step 4. Set the number of hidden layers and nodes, learning rate, activation function, and other parameters of the recurrent neural network, and use multiple groups of training data to train the RNN mining model.

Step 5. Mine the samples by using the trained model and superimpose all the mining values; that is, complete the data mining of evaluation of college mathematics teaching quality.

3. Implementation of Mathematics Teaching Quality Evaluation

Combined with the evaluation model constructed above, the evaluation of college mathematics teaching quality can be carried out through the following two steps: constructing the index system and completing the mathematics teaching quality evaluation.

3.1. Establishment of Evaluation Index System. Aiming at the four main components of the mathematics teaching model, this study selects three dimensions of mathematics teaching: before, during, and after to construct the evaluation index system of teaching quality. The selection of evaluation indicators is complex. Firstly, the evaluation index system of mathematics teaching quality can be preliminarily constructed by expert interview method [20, 21], then the key evaluation indexes should be optimized, and finally, the weight of different evaluation indexes can be clarified by AHP. The construction flow chart of evaluation index system is shown in Figure 3.

Combined with the above figure, it can be seen that the four evaluation indicators are applied based on the dimension of before mathematics teaching, namely, investment, participation, learning ability, and guidance. In the process of mathematics teaching, the four evaluation indexes of input, participation,

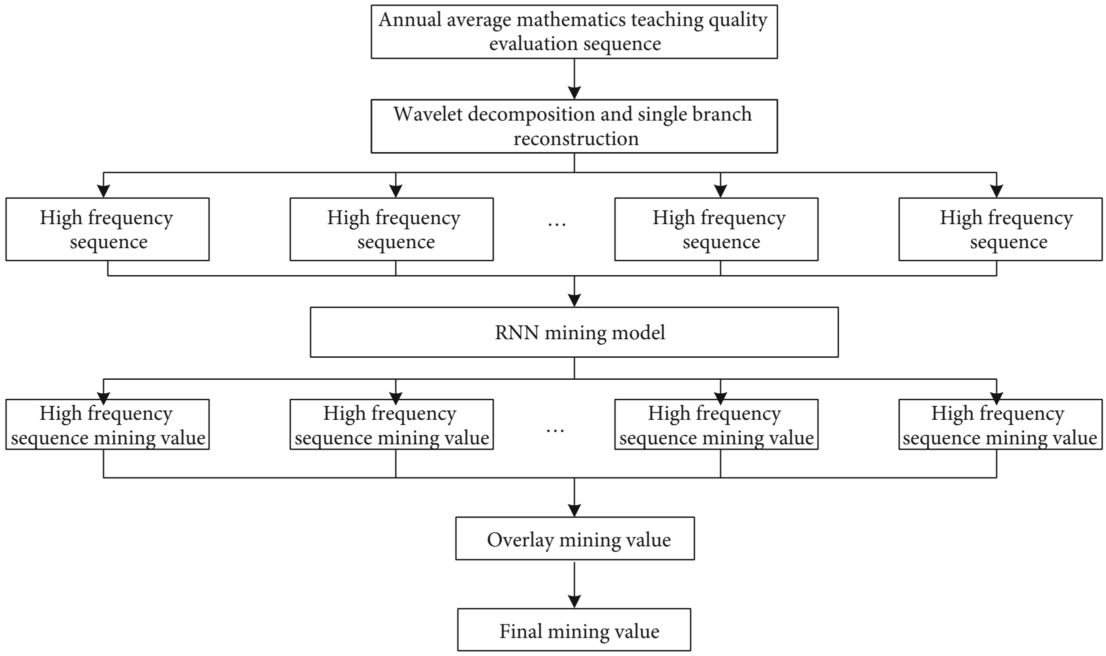


FIGURE 2: Structure diagram of data mining model for mathematics teaching quality evaluation.

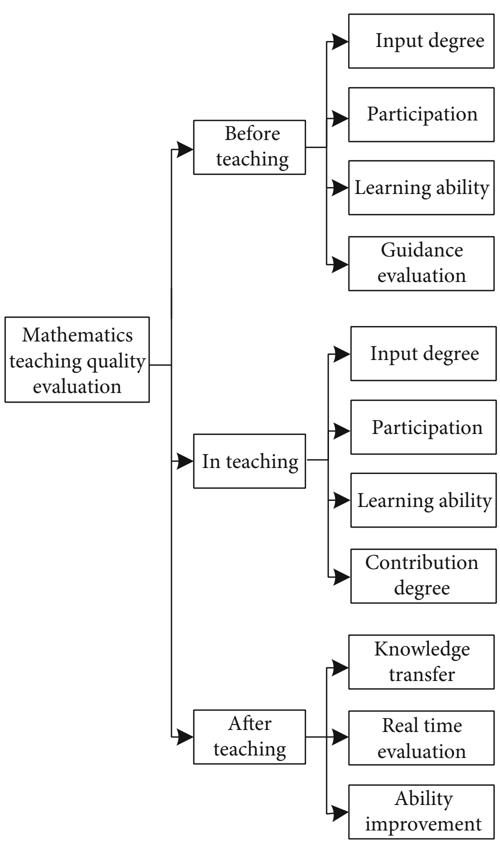


FIGURE 3: The construction flow chart of evaluation index system of mathematics teaching quality.

learning ability, and contribution are applied. After the completion of mathematics teaching, the three evaluation indexes applied are knowledge transfer, real-time evaluation, and ability improvement.

The evaluation index system of mathematics teaching applies the method of combining qualitative and quantitative evaluation and realizes the comprehensive evaluation and monitoring of the teaching state [21].

3.2. Evaluation of Mathematics Teaching Quality Based on Big Data Analysis

3.2.1. Evaluation Index Data Fusion. Through the feature extraction method of association rules, the association rules are extracted according to the evaluation index data of mathematics teaching quality [22], and the phase space distribution W of big data is established, which can be regarded as a judgment matrix $n \times m$. ρ_q and $P(n_i)$ are used to represent the characteristic distribution vector and probability distribution function, respectively, so as to realize the effective fusion of evaluation index data of mathematics teaching quality [23, 24]. When constructing the regression analysis model of data, it is necessary to make statistical analysis on the data related to the evaluation index of mathematics teaching quality under the method of regression analysis and clarify the data association rules. The calculation formula is

$$y(t) = \rho_q \sum_{i=0}^{n} \theta P(n_i) s_i(t). \quad (11)$$

In the above formula, the number of interference items and the probability distribution of the evaluation index are expressed by $s_i(t)$ and θ. The membership function in the fuzzy comprehensive evaluation of teaching quality evaluation data can be determined through the following formula, which is specifically expressed as

$$R = l\sum_{i=0}^{n}\left(R_s^{(i)}, d_{\gamma n}\right) + y(t), \tag{12}$$

where $R_s^{(i)}$ represents the distribution characteristic quantity of big data, $d_{\gamma n}$ represents the number of data reconstruction, and l represents the evaluation iteration coefficient. According to the above analysis, the fusion formula of evaluation index data of mathematics teaching quality can be obtained as follows:

$$G(t) = w \min \{R + Y_t\}. \tag{13}$$

The fusion of big data related to mathematics teaching quality evaluation indicators can be realized by using formula (13).

3.2.2. Implementation of Mathematics Teaching Quality Evaluation. In addition to the data fusion processing of mathematics teaching quality evaluation indicators, it is also necessary to analyze and explain parameters and control variables with the help of constraint analysis method [25, 26], so as to effectively implement teaching evaluation. δ is the implicit state in the evaluation process, and η is the observation state in the evaluation process, so as to determine the fuzzy numerical function. The calculation formula is

$$M = \eta\sum_{i=1}^{n}\delta G(t). \tag{14}$$

Under the above formula, the limited large data set related to the evaluation index can be obtained by combining the data mining technology of joint association rules. At the same time, support vector machine learning method and adaptive learning thinking can be used to clear the feature relationship of quantitative evaluation.

$$Q(t) = \eta\sum_{i=1}^{n}\delta G(t)e^{s_i(t)}. \tag{15}$$

Using the optimization model of support vector machine classification algorithm, the mathematics teaching quality evaluation data can be evaluated and classified. The final evaluation result of mathematics teaching quality can be obtained by method of average statistics. The objective function is described below:

$$\min = w\sum_{i=1}^{n}\delta G(t)e^{s_i(t)} + Y_t^{\mathrm{T}}. \tag{16}$$

Using the above process, we can complete the evaluation of mathematics teaching quality.

4. Experimental Analysis

4.1. Preparation for Experiment. In the experimental testing of the model proposed in this study, the distribute cluster carrying relevant evaluation data needs to be constructed first to make the evaluation data have good scalability. The cluster adopts the form of sharding+replica sets and adopts three hosts (server A, server B, and server C) to realize the replication sets of two mathematics teaching quality evaluation in the distributed cluster, which are marked as set 1 and set 2, respectively.

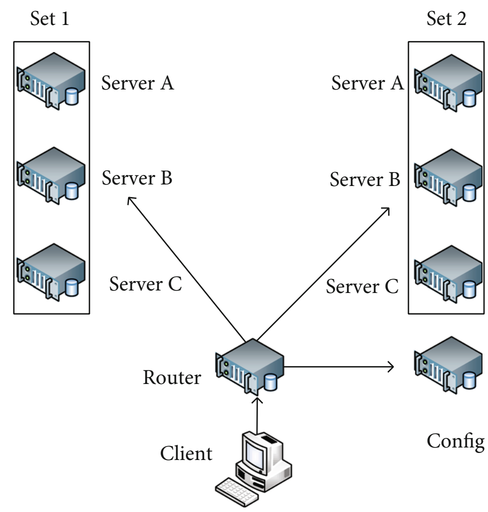


Figure 4: Logic structure.

In the logical structure shown in Figure 4, the model node uses the 64 bit of CentOS 7. X series operating system. The host IP address and port settings are shown in the following table.

According to the host IP address and port shown in Table 1, select the server with CPU of 2.40 GHz, i5-6200u, and hardware storage of 2.0 g. The configuration of the three servers is the same. Prepare the number of mathematics teaching quality evaluation data samples required for the experiment, and divide the mathematics teaching quality evaluation into different class attribute codes. The prepared data sets are shown in Table 2.

Using the sample data of teaching quality evaluation in the above table, experiments are carried out using reference [8] genetic algorithm evaluation model, reference [9] fuzzy mathematics and machine learning algorithm evaluation model, and mathematics teaching quality evaluation model based on recurrent neural network.

4.2. Experimental Results. In the process of processing a large number of evaluation data under different indicators, normalization processing method is used to complete the data processing task more quickly and efficiently. The data normalization formula is shown as follows:

$$x = \frac{x - x_{\min}}{x_{\max} - x_{\min}}. \tag{17}$$

In formula (17), the maximum value of the initial sequence is represented by $x_{\min}$ and the maximum value of the initial sequence is represented by $x_{\max}$.

For the initial sequence, wavelet classification and the single branch reconstruction experiment can be carried out

Table 1: IP address and port of experimental host.

Host	IP address	Service port
Service A	192.168.118.100	Mongod shard 1-1:35046 priority:2 Mongod shard2-1:35045 arbiteronlyarue Mongod config 1:18000
Service B	192.168.118.101	Mongod shardl-2:35405 priority:l Mongod shard2-2:35047 priority:l Mongod config 2:19000
Service C	192.168.118.102	Mongod shard 1-3:26057 arbiteronlyarue Mongod shard2-3:26706 priority:2 Mongod config 3:20000

Table 2: Number of samples prepared for the experiment.

Class attribute code	Number of samples (group)	
	Data set 1	Data set 2
0	1002	488
1	989	499
2	980	406
3	1008	456
4	978	508
5	996	358
6	1026	438
7	968	368
8	958	410

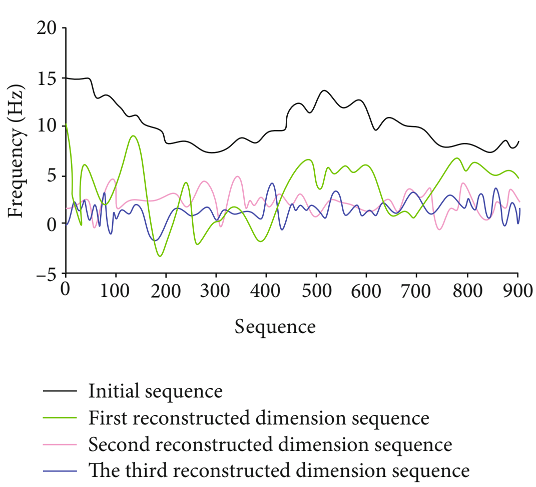


Figure 5: Schematic diagram of high-frequency sequence comparison.

by wavelet transform analysis. The specific results are shown in Figure 5.

According to the figure above, it can be seen that the high-frequency sequence captured after splitting and reconstruction can reduce the interference to the initial sequence, which can significantly reduce the number of parameters and greatly improve the convergence, so as to retain the effective information in the initial sequence.

Based on the training samples and test samples, 1000 data samples are selected, and three methods are used to compare the effect of data mining in the evaluation of mathematics teaching quality. The test results are shown in Figure 6.

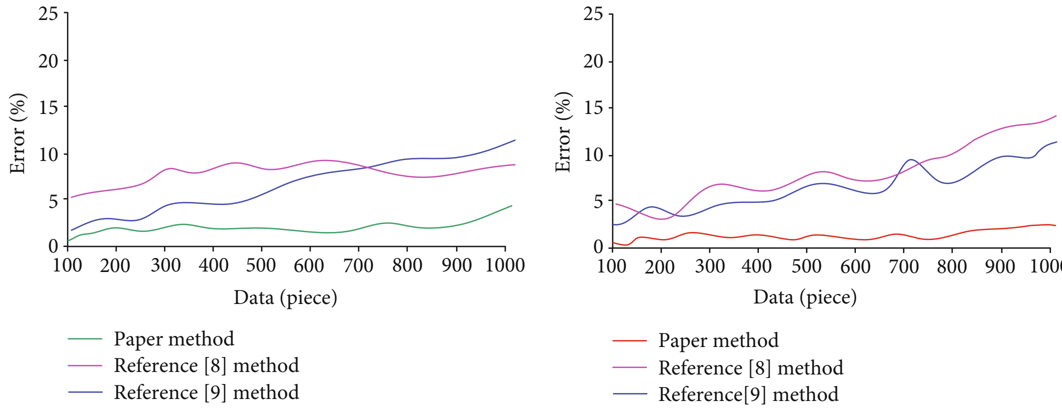
According to the above figure, it can be found that in the training and test results of data samples for mathematics teaching quality evaluation, the training and test error by using this method is the smallest, the average values of training error and test error are 3.02% and 2.61%, respectively, and the value of the former is lower than that of reference [8] and reference [9], indicating that this paper has good application value of data mining for mathematics teaching quality evaluation. The main reason is that this paper uses recurrent neural network to process the sample data, which improves the evaluation performance.

Taking mathematics teaching before, during, and after mathematics teaching as the test content, this paper compares the fitting degree of the three methods between the evaluation results of mathematics teaching quality and the set results. The results are shown in Figure 7.

According to the figure, the final evaluation accuracy of the mathematics teaching quality evaluation model based on recurrent neural network proposed in this study is relatively high, and the evaluation results are in good consistency with the set results, which is obviously better than the evaluation methods in references [8, 9]. This fully shows that the evaluation model proposed in this study has good performance and can accurately evaluate the quality of mathematics teaching. The main reason is that this method reconstructs and decomposes the mathematics teaching quality evaluation in advance, improves the quality and accuracy of the data in the input evaluation model, and further optimizes the fitting effect.

The model proposed in this study is also applied to test and analyze the effectiveness of big data fusion of evaluation index under the set experimental environment. The big data fusion efficiency test results of this model are shown in Figure 8 under the condition of the amount of data related to different evaluation indicators.

It can be found from the above figure that in the mathematics teaching quality evaluation index system constructed in this study, the data of different dimensions show high fusion efficiency. When the total amount of data of each dimension is 5000, the fusion time of three-dimensional data is within 800 ms. Therefore, it can be explained that this



(a) Training error comparison results

(b) Test error comparison results

Figure 6: Schematic diagram of error comparison results.

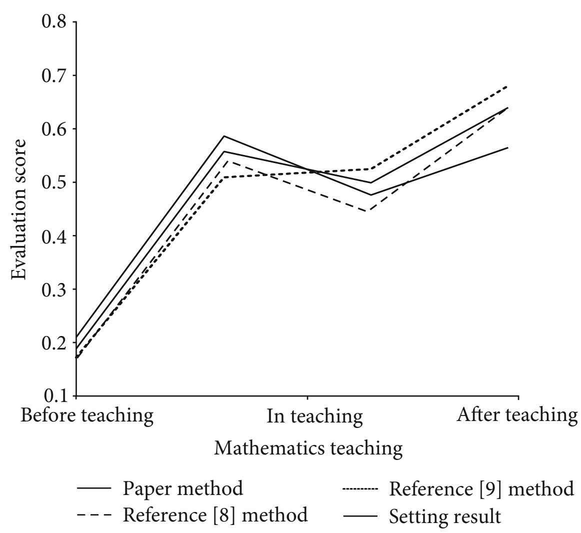


Figure 7: Comparison of evaluation results of different methods.

method can quickly fuse the data in each dimension, which significantly improves the evaluation level of mathematics teaching quality and is of great help to improve mathematics teaching efficiency.

Compare the overall efficiency of this method and the evaluation methods in references [8, 9]. The comparison results are shown in Figure 9.

According to the figure above, it can be seen that there are certain differences in the overall efficiency of the above three different evaluation methods, among which the evaluation model proposed in this study takes the shortest time, less than 1.2 s. The average time of reference [8] method is the longest, which is about 1.0 s higher than that of this method. The method of reference [9] has the largest time fluctuation, and the average time is about 0.9 s higher than that of this method. The above data fully shows that this method has high evaluation efficiency.

In this study, four students are selected to carry out the evaluation by using the evaluation model of mathematics teaching quality based on recurrent neural network, and the mathematics teaching model was adjusted and reformed according to the final evaluation results, so as to improve the teaching efficiency. Take the grades as an example. Compare the changes in mathematics scores within one academic year after adopting the method in this paper (compare the total scores at the end of the same academic year). The specific results are as follows.

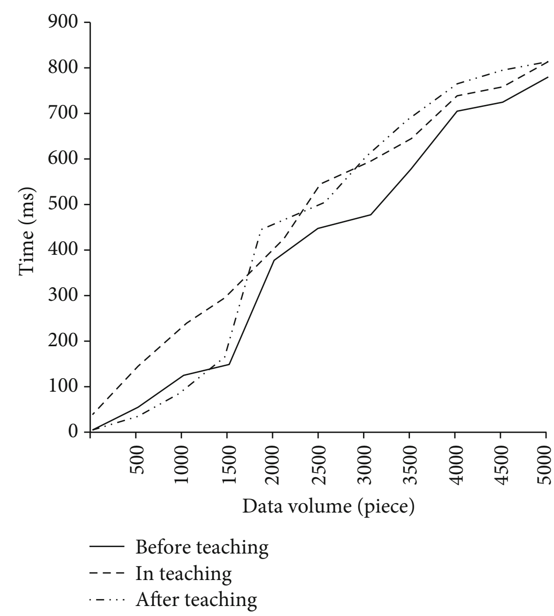


Figure 8: The efficiency of big data fusion.

According to the analysis of Table 3, after adopting the method in this paper, the overall performance of mathematics performance has been continuously improved, the mathematics teaching achievement has been significantly improved in the last semester, and the growth of mathematics teaching results in the next semester is at a stable level. After using this model to evaluate the mathematics teaching quality and optimizing the mathematics teaching mode, the improvement in mathematics scores reached 10 points or more. It shows that the evaluation model proposed in this study has good practicability and effectiveness and is worthy of wide promotion.

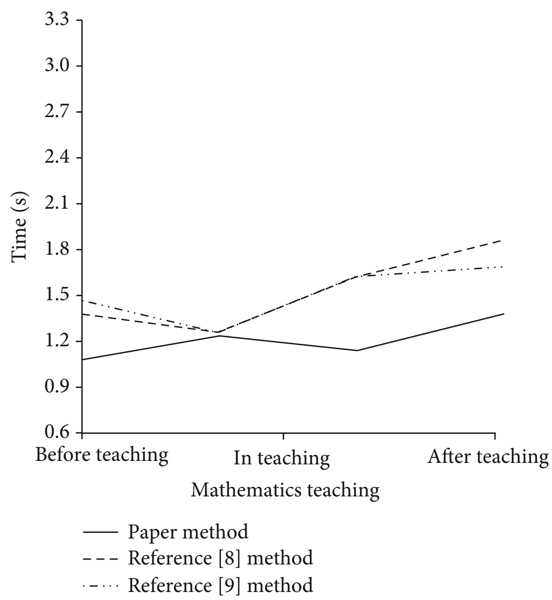


Figure 9: Comparison of overall efficiency results.

Table 3: Comparison table of mathematics teaching achievements.

Grade change score (point)	Time (month)					
	2	4	6	8	10	12
10						√
9					√	
8						
7				√		
6			√			
5		√				
4						
3						
2	√					
1						
0						
-1						
-2						

5. Conclusion

Based on the decomposition and reconstruction of the initial sequence of mathematics teaching quality evaluation by wavelet transform, this paper substitutes it into the cyclic neural network model to carry out data training and construct the mathematics teaching quality evaluation model. This method has better fault tolerance, stronger approximation ability, and anti-intrusion ability and has good mining and generalization ability. Experiments show that the performance improvement of the mathematics teaching quality evaluation method proposed in this paper has reached 10 points or more, and the application teaching quality is good, which is worthy of wide promotion. In the next step, it can be applied to multiple departments of multiple colleges and universities for application experiments, so as to further improve the universal teaching quality of the practical application of this method.

Data Availability

The authors can provide all the original data involved in the research.

Conflicts of Interest

There is no conflict of interest in this study.

Acknowledgments

This work supported by the 2021 Chongqing Universities Demonstration Project of Ideological and Political Theories Teaching in All Courses, “Engineering Mathematics” (2021-148); “Thirteenth Five-Year Plan” Key Project of Chongqing Education Science, “On Intelligent Adaptive Online Learning Behavior in the Background of Big Data” (2018-GX-157); and Humanities and Social Sciences Project of Chongqing Municipal Education Commission, “On the Construction and Application of SPOC Teaching Mode from the Perspective of ‘Internet + Education’” (19SKGH240).

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