Network Game of Student Training Quality Assessment System Based on KOHONEN Neural Network

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Objectives: In recent years, with the continuous improvement of the requirements of student training quality, the evaluation results of the existing evaluation system of student training quality are mostly unsatisfactory. Therefore, by integrating c-mean algorithm and Kohonen clustering algorithm, a non-sequential artificial neural network is obtained, a student training quality evaluation system based on KOHONEN neural network is designed by automatically adjusting the size of the objective function nodes of the non-sequential artificial neural network. Then the evaluation system is applied to the expected evaluation of the training quality of students in two science classes of Xinghua Middle School in Shenyang, Liaoning Province. The comparison between the test result data and the expected results of the model after the experiment confirms that the evaluation results obtained by using the evaluation system based on KOHONEN neural network have high accuracy.

Key words: kohonen neural network; evaluation system; c-means algorithm; fcm objective function
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With the development of economy and the progress of society, the competition situation in society is becoming more and more severe, the social structure is becoming more complex, and the problems to be dealt with are more diversified, which make the social demand for talents have changed a lot. What's more, it is the educational activities for talents that determine the ability of talents. Therefore, higher requirements have been put forward for education, from the previous single skill training needs to a more comprehensive training requirements.[1] The state has also put forward clear requirements for the cultivation of talents in the new era. It is necessary to strengthen the cultivation of student innovative ability and practical ability, and comprehensively improve the humanities and scientific qualities of students. Educational institutions such as schools are also following the policy requirements and comprehensively strengthening student development. Along with this is the quality assessment of student development.[2] Evaluators need to use a variety of different assessment methods to assess the quality of student development, which undoubtedly further increases the workload of quality assessment. If the work arrangement is unreasonable, it will reduce the quality of the assessment work and even affect the accuracy of the education evaluation, which is not conducive to the development of post-education work.[3]

With the development of computer technology, the rapid rise of neural networks has brought new and improved ideas for student quality assessment.[4] The current assessment of student development quality is mainly based on manual review, which leads to not only the assessment workload is huge, but also the problem of assessing subjectivity is too strong.[5] Introducing the neural network into the quality assessment system, with the help of reasonable algorithms, the subjectivity of the assessment can be effectively reduced, and the evaluation results are more objective. Moreover, due to the powerful computing power of the computer, it will not be dragged down by the huge workload, which effectively improves the efficiency of quality assessment.[6] The following are the main innovations: (1) At present, most of the existing evaluation systems of student training quality are designed with the traditional AHP analytic hierarchy process (AHP), and most of the basic data of evaluation are obtained by manual management, which makes the evaluation results often interfered by human factors and become inaccurate. And a non-sequential artificial neural network is obtained by integrating c-mean algorithm and Kohonen clustering algorithm. By automatically adjusting the size of FCM objective function nodes of non-sequential artificial neural network, an innovative student training quality evaluation system based on KOHONEN neural network is designed. (2) In order to verify the actual effect of the model, the KOHONEN-based student training quality evaluation system is applied to the evaluation of the student training quality of the third and fourth classes of the junior middle school of Xinghua Middle School in Shenyang, Liaoning Province and the correctness of the theoretical model is verified by real data.

The organizational structure of this paper is as follows: The first section mainly elaborates the research background and the organizational structure of the article. The second section mainly describes the status quo of student training quality assessment. The third section mainly states the design process of the student training quality evaluation system based on KOHONEN neural network. The fourth section mainly elaborates the practical application process of the evaluation system in the expected evaluation of the training quality of students in two science classes of Xinghua Middle School in Shenyang City, Liaoning Province. The fifth section mainly summarizes the research results.

In order to improve the efficiency and accuracy of student training quality assessment, efforts are being made all over the world. Compared with the developing countries, the developed countries have abundant research results in this field, such as NCR company has developed data warehouse technology for student training, and Ectel Company has developed synchronous detection technology. Scholar Smith believes that these advanced student training quality assessment techniques have improved the accuracy of quality assessment and provided a basis for improving student training programs.[7] Luo S, a scholar, put forward that the principle of student training data warehouse technology and synchronous detection technology is very similar to that of evaluating the quality of student training. Firstly, it is necessary to clarify the purpose and detailed indicators of student training, then collect the corresponding indicators in student training work, after that, compare and analyze the collected data with the established target data. Finally, a detailed quality assessment report is obtained, the student development plan is then adjusted according to the detailed analysis report.[8]

Scholar Nemtanu F found that HP Company proposed a special evaluation method for the students of higher education. The basic principle is to first determine the orientation of the quality assessment system, as the direction of the assessment indicators represents the direction of the teaching development plan.[9] Therefore, it has made targeted adjustments to the evaluation indicators, such as the identification of courses and dissertations. After further research, scholar Narayanan V H quantified this indicator and quantifies the objectivity of the assessment.[10] In this way, it can be realized that in the actual evaluation process, changing the quality evaluation system can track one of the single indicators in real time, and will not affect the monitoring of other indicators. Scholar Royer S proposed that if the indicators exceed the pre-set safety values of the evaluators in the process of tracking analysis, the quality evaluation system would immediately alert the evaluators to warn them of possible problems in the quality of training of the evaluators.[11] At the same time, the quality evaluation system can also set the weight of the detection index freely by the evaluators. Scholar KU rten N proposed to define serious events and weighting coefficients according to different weights. Different indicators can also set different thresholds to achieve flexible evaluation of various training plans.[12]

At present, the research on the evaluation system of student training quality in China is still in the preliminary stage, and there is no special evaluation system of student training quality. Scholar Mathews T argued that most educational institutions conduct quality assessment through traditional summary examinations. Although the assessment process was very convenient, there were many unstable factors and the evaluation results are not comprehensive enough.[13] Through the analysis of the evaluation system of student training quality at home and abroad, it can be clearly see that there are abundant evaluation systems of student training quality in foreign countries at present. All kinds of evaluation systems are more convenient, and the accuracy of evaluation results is also higher. Compared with foreign countries, domestic research on the evaluation system of student training quality has just started, and it is carried out by using relatively backward methods. In general, the current assessment of student training quality requires pre-set reference values for relevant indicators, and then compares the collected data with the reference values during the evaluation process. The final evaluation conclusion is that this process relies too much on the pre-set reference value, which needs to be reset when the quality evaluation object changes. Moreover, whether the reference value is set reasonably or not directly determines the accuracy of the evaluation results.

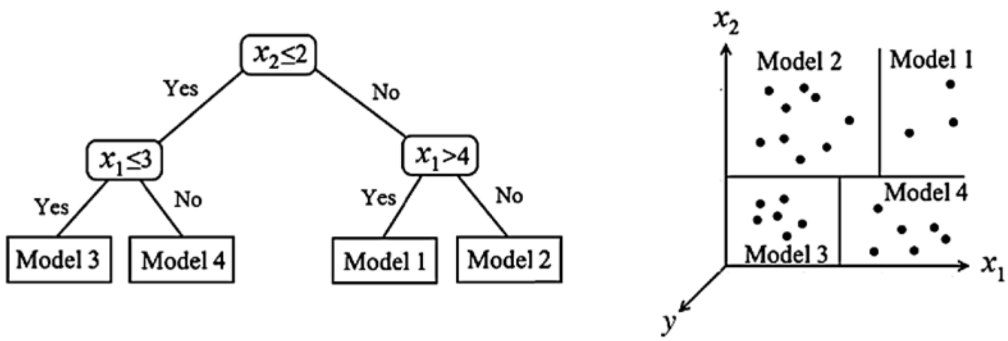
METHODS

Artificial Neural Network

The human brain is made up of a large number of neurons, which form a neural network through their connections, and then are combined by the majority of networks. Finally, the basic functions of the brain are completed. The structure of the neuron is as follows: (1) Soma: a nuclear processing mechanism consisting of the cytoplasm and nucleus of the main body of the neuron. (2) Axon: the longest outward branch of a neuron, which serves as the output connection of a cell, i.e. the output terminal of a neuron; the nerve cell is an axonal transport mechanism. (3) Dendrite (dendrite): the longest outward branch of a neuron, serving as the output terminal of a cell; the nerve cell is an axonal transport mechanism. (4) Synapses: the junction of axons and dendrites; the punctate connective structure on the nerve tree.

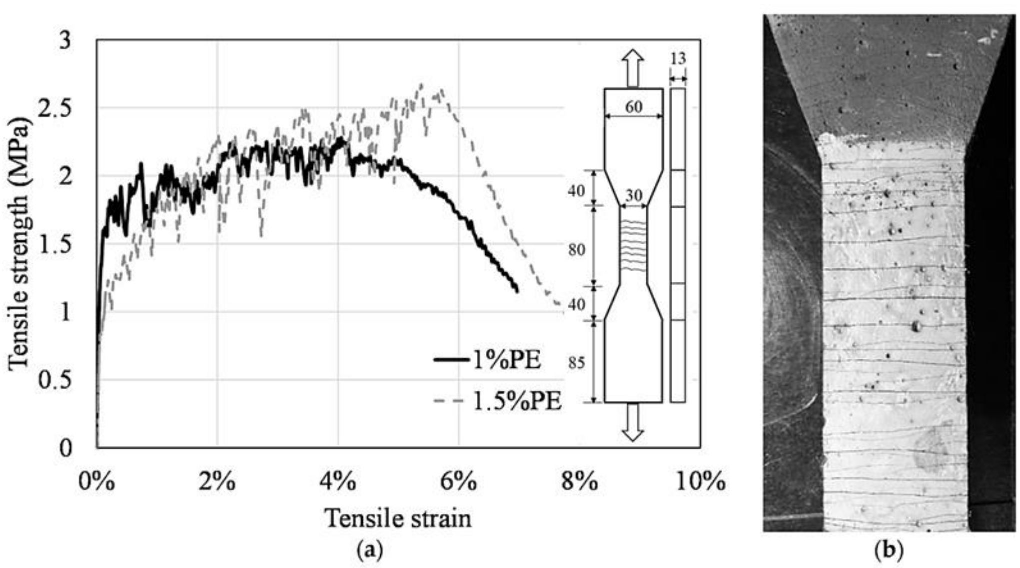
When the external stimulus is generated, all signals transmitted through dendrites are determined by synapse. When the signal intensity accumulates beyond a certain threshold, it is transmitted to the next neuron.[14] Neurons are the basic components of the nervous system. They are constructed like ordinary semiconductor components. They receive signals, collect them, and send out results from the other side. However, the function of neurons is more complex than that of semiconductor components. Therefore, to simulate the operation of neurons and make an artificial neuron is always the focus of scientists' research. In the study of neuron models, it is hoped to achieve the following objectives: (1) Whether artificial neurons can complete the complex functions of neural networks. (2) Whether the characteristics of artificial neurons are similar to actual neurons. (3) Whether the ability of artificial neurons to solve problems is as accurate as that of the human brain.[15] Artificial neural network, also known as parallel distributed processors, adaptive systems, self-organizing systems, connectionism schemes, etc., And this information processing system is designed on the basis of imitating biological neural network. It is more precisely defined as: artificial neural network is a computing system, including hardware and software, which uses a large number of simple related artificial neurons to imitate the ability of biological neural network. Artificial neuron is a simple simulation of biological neurons. It obtains information from the outside environment or other artificial neurons, calculates it, and then outputs the results to the outside environment or other artificial neurons. There is often a causal relationship between the operation of a machine or the occurrence of an event, just as the action of switching on the switch and picking the foot brake is called the input of the system, TV and car are called the system, and the operation of TV and car immediately stop is called the output of the system (Figure 1).

Figure 1
The mathematical model of the gray mean



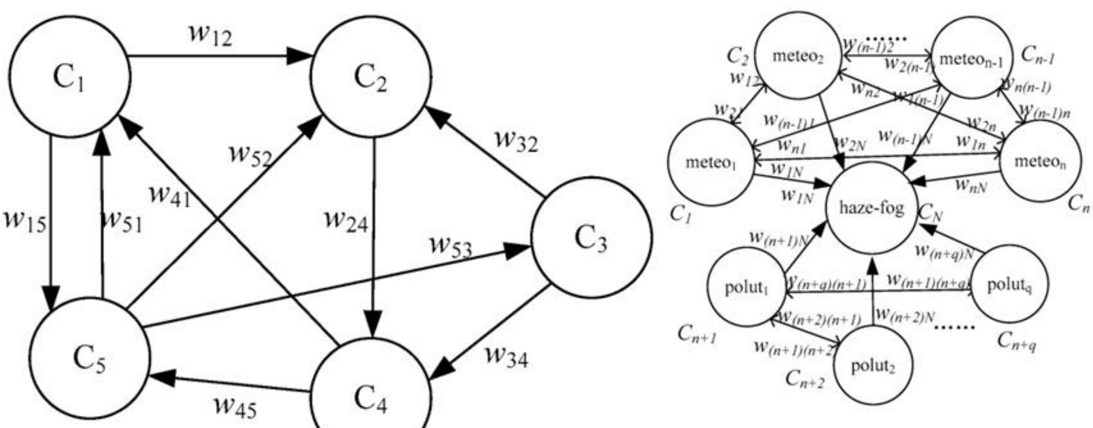
Artificial neural network theory originated in the 1950s, when scientists began to propose a neural model called perceptron to open up the field of application of artificial neural network, following the organization and operation of human brain. But before 1980, because the expert system was the most popular artificial intelligence foundation at that time, and the theory of artificial neural network was still immature, the artificial neural network did not receive much attention. It was not until the 1980s that the Hopfield neural network was proposed, and at this time the expert system began to encounter bottlenecks, and artificial neural network theory was gradually taken seriously. Until now, new structures and theories of artificial neural networks have been proposed continuously. With the increase of computer instruction cycle, artificial neural networks have more powerful functions and more extensive application levels, including classification, prediction, recognition and so on (Figure 2).

Figure 2
Artificial neural networks still have new structures and theories constantly put forward



The artificial neural network is an information processing system that imitates the biological neural network. According to the learning strategy, the artificial neural network can be divided into the following categories: (1) Supervised learning network. The supervised learning network is to obtain the input variable value of the training paradigm from the problem and the corresponding target output variable value, and learn the intrinsic mapping rules of the input variable and the output variable to apply to the new problems in the future (using input variables to derive output variables) (Figure 3). For example: Back-Propagation Network, Counter-Propagation Network; (2) Unsupervised learning network. The training paradigm of the unsupervised learning network is only the input variable value, from which the network learns the relationship of the inner cluster to apply to the new problems (there is an input variable value, and it is necessary to infer which cluster belongs to which question). For example: Self-Organizing Map (SOM), Adaptive Resonance Theory Network (ART); (3) Associative learning network. The associative learning network obtains the training paradigm (state variable value) from the problem domain, and learns the intrinsic memory rules of the paradigm to apply to the new problem (using the incomplete state variable value to infer the complete state variable value). For example: Hopfield Neural Network and Bi-directional Associative Memory.

Figure 3
Supervised learning networks derive training examples from problems



***Notes:** *N=n+q+1**

Kohonen Algorithm

Kohonen algorithm integrates learning speed and strategy updating in FCM and Kohonen cluster network. Therefore, it produces an optimization problem about FCM, which can not only improve convergence, and also reduce markup errors. FKCN and c-Means algorithms are equal, so Kohonen algorithm can be regarded as Kohonen form of fuzzy c-means algorithm. FKCN is a kind of self-organization because the size of updating neighborhood and learning rate is automatically adjusted in the competitive layer when learning. Kohonen algorithm is a new algorithm which integrates c-mean algorithm and Kohonen clustering algorithm. It is a method to point out several problems of KCN and why CM and KCN are similar. Each step of Kohonen algorithm is the same as that of FCM or strict HCM (hard c-Means). In addition, Kohonen algorithm updates the size of neighboring nodes automatically when learning, and it often terminates when the FCM objective function is close to the minimum. Kohonen algorithm is a non-sequential artificial neural network, so the order of input data is independent (the order of data input will not affect it). In FKCN, the restriction of nodes near KCN will be relaxed, but it will be added to the learning rate strategy. Kohonen clustering networks can be identified using the following abstract fitting functions:

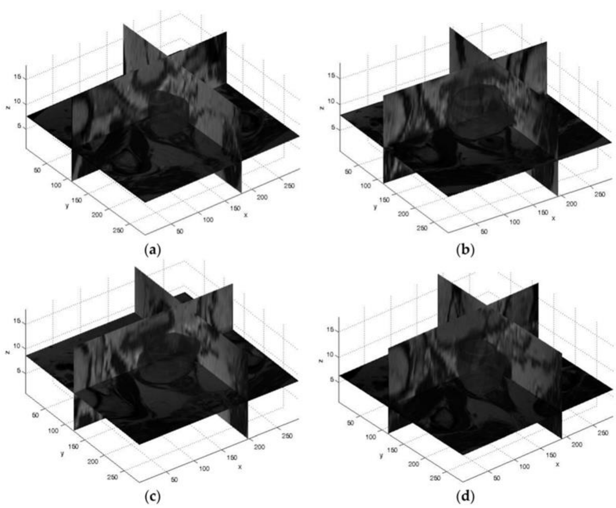
$$
\begin{aligned}
E(c_1,c_2,C) = {} & \mu \cdot L(C) + \upsilon \cdot A(inside(C)) \\
& + \lambda_1 \int_{inside(C)} \left| u_0(x, y - c_1) \right|^2 dxdy \\
& + \lambda_2 \int_{outside(C)} \left| u_0(x, y - c_2) \right|^2 dxdy
\end{aligned} \quad (1)
$$

The coefficients of each item in the formula $\mu \geq 0$, $\upsilon \geq 0$, λ_1, $\lambda_2 > 0$, $L(C)$ is the length of the closed curve C and $A(inside(C))$ is the area of the inner area of the closed curve C. When the closed curve C is not located at the boundary of two homogeneous regions, the curve fitting function $E(c_1, c_2, C)$ is greater than zero and cannot reach the minimum value (as shown in Figure 4); only when the closed curve C is located at the boundary of two homogeneous regions, the fitting function $E(c_1, c_2, C)$ is the minimum value. The length of the closed curve C expressed by the level set and the inner area of the curve (as shown in Figure 2) are as follows:

$$L\{\phi = 0\} = \int_\Omega \left| \nabla H(\phi(x, y)) \right| dxdy = \int_\Omega \delta_0(\phi(x, y)) \left| \nabla \phi(x, y) \right| dxdy \quad (2)$$

$$A\{\phi \geq 0\} = \int_\Omega H(\phi(x, y)) dxdy \quad (3)$$

Figure 4
Curve fitting function at the boundary of two homogeneous regions inside the curve



Since the Kohonen clustering network expresses closed curve C as zero level set, and defines that the value of level set function inside closed curve is greater than zero, and vice versa, the value of level set function outside curve is less than zero, the equation satisfied by level set function $\phi(x, y)$ can be obtained by variational method.

$$\frac{\partial \phi}{\partial t} = \delta_\varepsilon(\phi) \left[\mu div\left(\frac{\nabla \phi}{|\nabla \phi|} \right) - \upsilon - \lambda_1 (u_0 - c_1)^2 + \lambda_2 (u_0 - c_2)^2 \right] \quad (4)$$

$$\frac{\partial \phi}{\partial t} = \delta_\varepsilon(\phi) \cdot \left(\mu \nabla \cdot \frac{\nabla \phi}{|\nabla \phi|} - \upsilon - \lambda_1 [u_0(x, y) - c_1]^2 + \lambda_2 [u_0(x, y) - c_2]^2 \right) \quad (5)$$

$$\phi(0, x, y) = \phi_0(x, y) \quad (6)$$

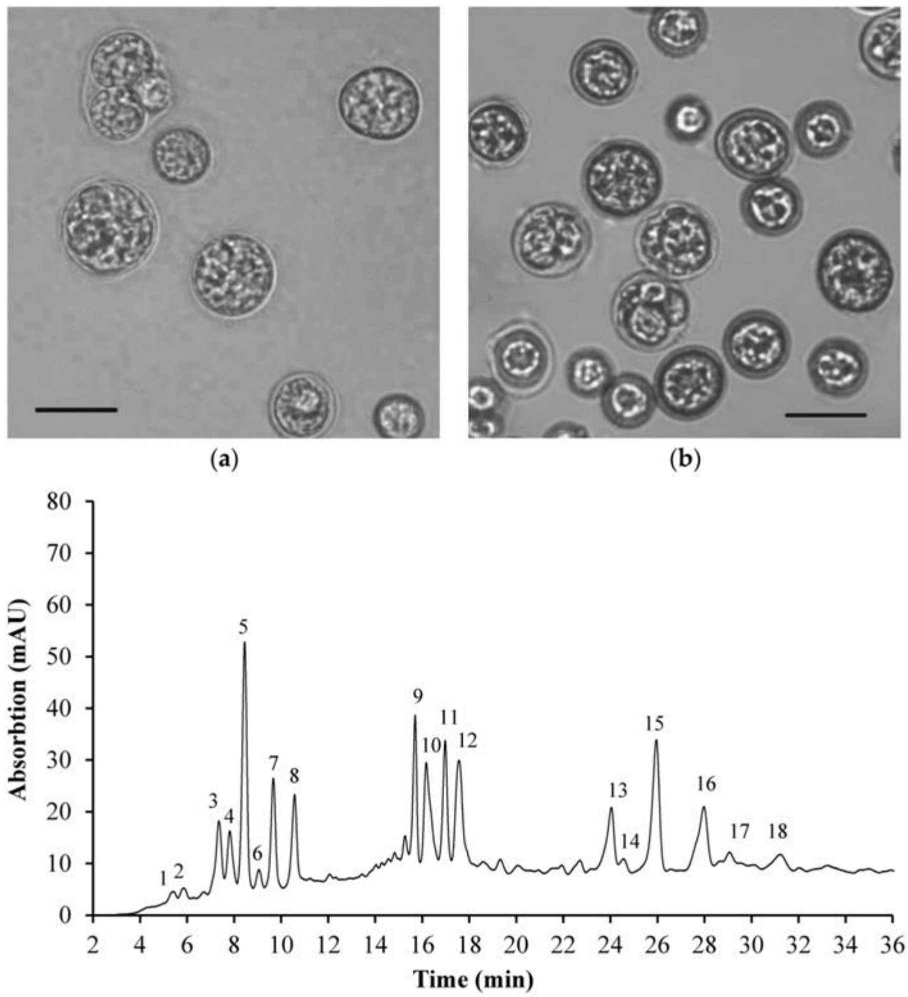
$$\frac{\partial(\phi)}{|\nabla \phi|} \cdot \frac{\partial \phi}{\partial n} = 0 \quad (7)$$

The constants c_1 and c_2 respectively represent the grayscale mean values of the inner and outer portions of the contour line C. After the function is simplified (Figure 5), it is generally represented by the following formula:

$$c_1 = \frac{\int_\Omega u_0(x, y) H(\phi(x, y)) dxdy}{\int_\Omega H(\phi(x, y)) dxdy} \quad (8)$$

$$c_2 = \frac{\int_\Omega u_0(x, y) \left(1 - H(\phi(x, y))\right) dxdy}{\int_\Omega \left(1 - H(\phi(x, y))\right) dxdy} \quad (9)$$

Figure 5
The mathematical model of the gray mean of the internal and external images of contour lines



Among them, Ω is the domain of the level set function and image, and $H(x)$ is the Heaviside function, as shown in formula (10). For convenience of description, H_ε can be abbreviated as H.

$$H_\varepsilon = \frac{1}{2}\left(1 + \frac{2}{\pi}\arctan\left(\frac{\phi}{\varepsilon}\right)\right) \quad (10)$$

$\delta(x)$ is the Dirac function, which is the derivative function of the Heaviside function, namely:

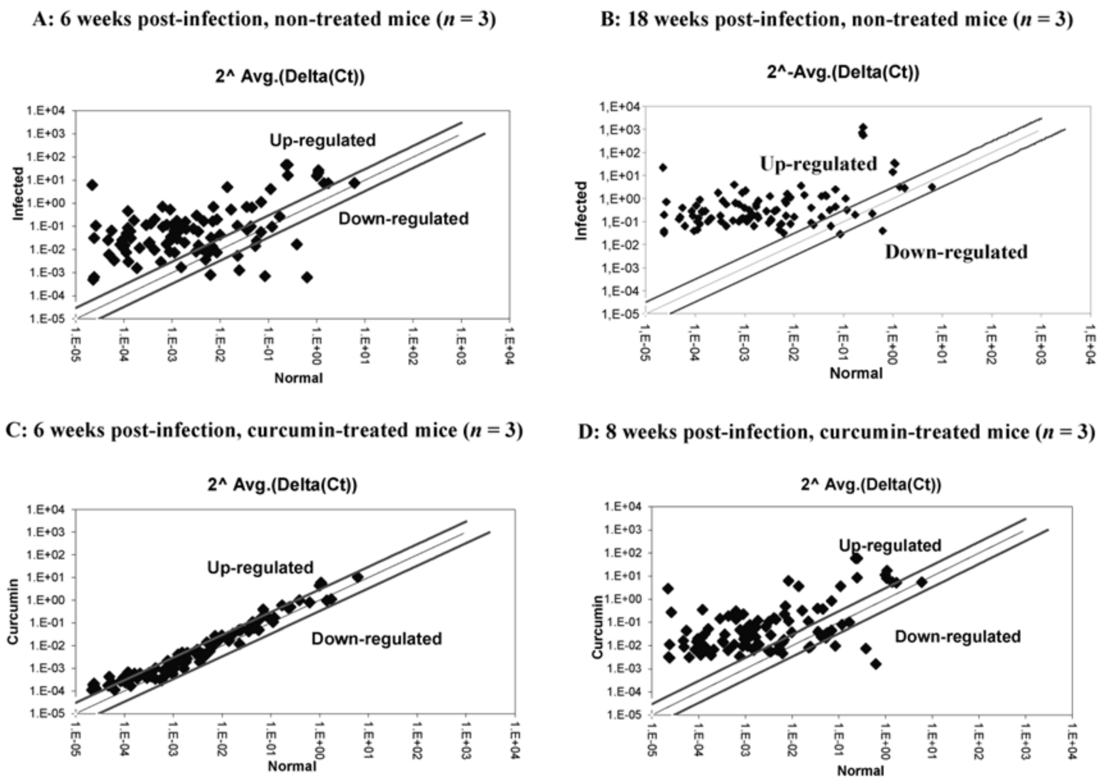
$$\delta_\varepsilon(\phi) = \frac{dH_\varepsilon}{d\phi} = \frac{1}{\pi}\frac{\varepsilon}{\varepsilon^2 + \phi^2} \quad (11)$$

In this formula, the variable n is mainly used to represent the normal direction of the zero level set.

Evaluation System Based on KOHONEN Neural Network

The evaluation system based on KOHONEN neural network is to lay the objects. The layering criteria are determined by the nature of the objects and their internal relations. The objects are divided into several layers for detailed analysis, so that the relative weights of each level can be obtained and ranked according to the analysis results. The evaluation functions commonly used in the evaluation system based on KOHONEN neural network are shown in Figure 6.

Figure 6
The commonly used evaluation function in AHP algorithm



The evaluation system based on KOHONEN neural network needs definite scaling of the specific weights of its various indicators at the beginning; after completing its index weight scale, it needs to construct the weight judgment matrix. The main reason is that the concrete calculation process is based on the judgment matrix. Through the judgment matrix, researchers can make a clear and accurate judgment on each level, so that they can quickly make the analysis results. Judgment matrices are usually divided according to the criteria of 1-9. For the three-level index structure, there are two types of judgment matrix: target criterion judgment matrix and criterion measure judgment matrix. The two types of judgment matrices have the same form, but different levels. The concrete forms are as follows:

$$\begin{pmatrix} a_{1,1} & a_{1,2} & \cdots & a_{1,n} \\ a_{2,1} & a_{2,2} & \cdots & a_{2,n} \\ . & . & . & . \\ a_{n,1} & a_{n,1} & & a_{n,n} \end{pmatrix} \quad (12)$$

In this formula, $a_{i,j}$ represents the relative weight of index a_i relative to index a_j.

In view of the fact that the weights of the evaluation system based on KOHONEN neural network have a great influence on the overall accuracy of the results obtained by scoring calculation, it is necessary to analyze the weights of the evaluation system based on KOHONEN neural network, which can be understood as the analysis of the maximum eigenvalues in the judgment matrix. The square root method is the most frequently used method of calculation. The calculation steps are as follows:

Calculate the product of each row element of the judgment matrix R.

$$M_i = \prod_{j=1}^{n} B_{ij}, i = 1, 2, \cdots, n \quad (13)$$

Calculate the n root of M_i.

$$\overline{w_i} = (M_i)^{\frac{1}{n}}, i = 1, 2, \cdots, n \quad (14)$$

$\overline{w_i}$ is normalized, i.e.

$$w_i - \frac{\overline{w_i}}{\sum_{i=1}^{n} \overline{w_i}}, i = 1, 2, \mathrm{K}\ , n \quad (15)$$

Then the weight vector

$$w = \left[w_1, w_2, \mathrm{K}\ , w_4\right]^T \quad (16)$$

Let the weight vector of the objective criterion layer obtained by the above method be

$$W = \left(w_1, w_2, w_3, \mathrm{K}\ , w_k\right) \quad (17)$$

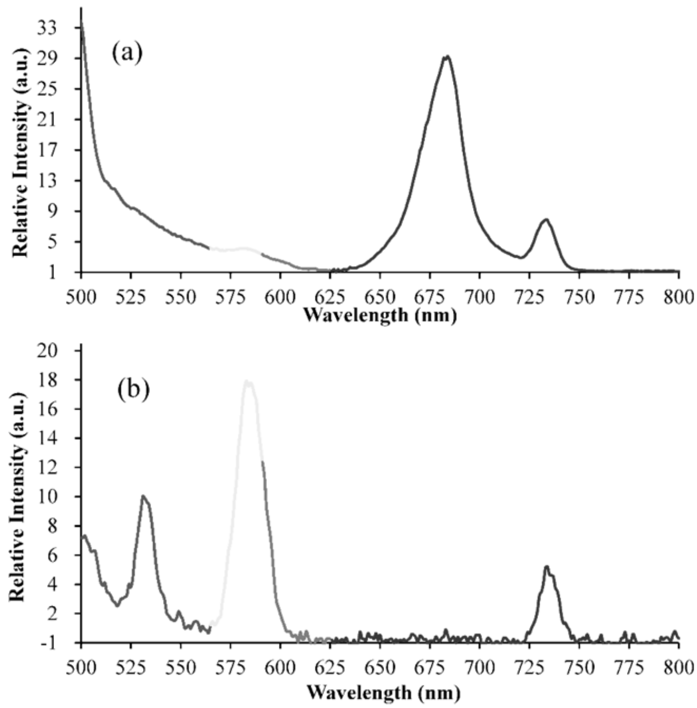
w_i is the relative weight of criterion level index i in criterion level.

By obtaining the evaluation indexes and multiplying the evaluation indexes with the evaluation values, the final evaluation scores are as follows:

$$Ea = \left(w_{p,1}, w_{p,2}, \mathrm{K}\ , w_{p,n}\right)\left(v_{p,1}, v_{p,2}, \mathrm{K}\ v_{p,n}\right)^T \quad (18)$$

$w_{p,i}$ is the comprehensive weight of the lowest index i, and $w_{p,i}$ is its evaluation score.

Figure 7
The evaluation index is multiplied the final evaluation score



RESULTS

Experimental Contents

This experiment mainly uses the junior high school students as the research object, and uses the control variable method and the control test method to construct the structured exercises for the students with the same preconditions (Figure 8). The quality of the student's training is then assessed using the KOHONEN neural network-based evaluation system designed above to improve the teaching model based on the results of the assessment.

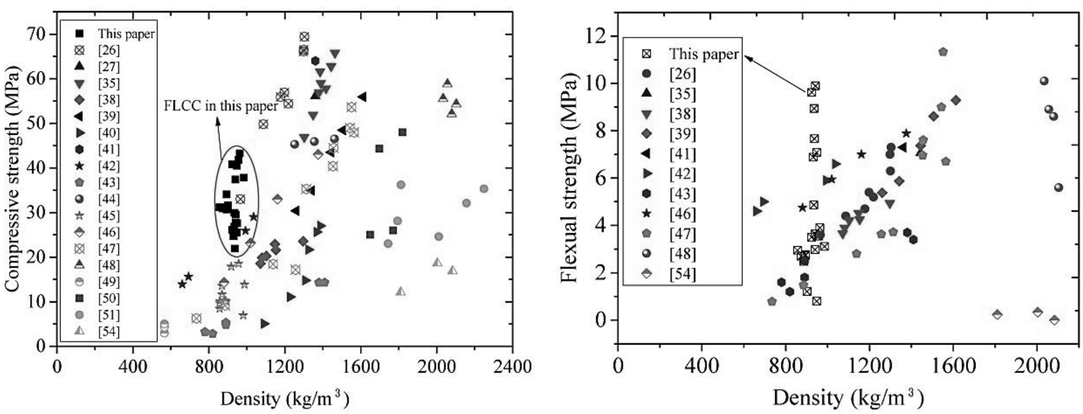
Figure 8
The class carries on the structure exercise teaching

Experimental Subjects

The subjects of this experiment are the students of Class 3 of Grade 1 and Class 4 of Grade 1 in Xinghua Middle School, Shenyang City, Liaoning Province. The average scores, passing rates and excellence rates of the two science classes in unit tests, mid-term tests and final tests within the last semester are basically the same (Figure 9), which meets the basic requirements of using the control variable method for experiments. The experimental implementation process is as follows: (1) Pre-experiment preparation, including the following aspects: Review the relevant research literature of junior high school mathematics structured exercises from the library, and actively organize the theoretical content of structured exercises. Then actively invite research scholars and education experts in this field to conduct research-based discussions, and combine the opinions of various parties before designing the experimental program. (2) Conduct a test on the respondent before the experiment (3) Pre-experimental training. (4) Experimental implementation. The implementation of the experiment is as follows: The third class of the first grade of the middle school of Xinghua Middle School is set as the control class, and the fourth class of the first grade of the middle school of Xinghua Middle School is set as the experimental class. For the control class, the teaching method of the problem is still to use the traditional teaching group to prepare lessons, and after the problem teaching program, the lectures are taught by the teachers in accordance with the problem teaching plan. In the process of problem-solving, the teachers of the department still use the problem-based teaching mode of the teacher-led classroom. The experimental class is taught in accordance with the teaching ideas of structured exercises. (5) After the experiment is completed, the subject is tested once.

Figure 9

The average score, pass rate and excellence rate of the final test

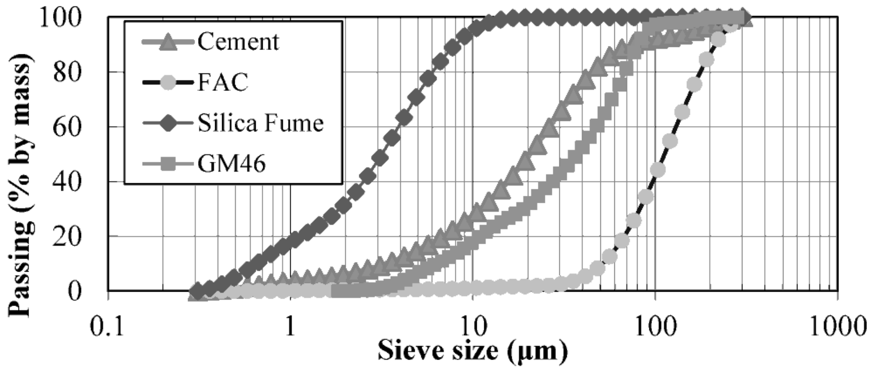


Application Evaluation

After obtaining the pre-student test data, a KOHONEN neural network-based evaluation system can be used to predict the quality of the student's training. The execution steps are as follows: find different evaluation indexes of the evaluated objects and establish an evaluation weight matrix R, calculate the product of each row element of the judgment matrix R and obtain the actual weight values of the different indexes of the evaluated object. The evaluation score can be calculated by calculating the weight values and the evaluation content data. The evaluation results can be obtained by calculating the data recorded in the experiment according to the above calculation method (Figure 10). The data in Figure 10 show that the homogeneity test of variance between the number of test scores and the expected evaluation data of the evaluation system is that, since the result is much larger than 0.10, it can be concluded that the expected results of the model evaluation are basically consistent with the results of the test after the completion of the experiment, which confirms that the evaluation results obtained by the KOHONEN neural network-based evaluation system have higher accuracy.

Figure10

Precision instrument of watt-hour meter tester with fault in transmission system



CONCLUSION

A non-sequential artificial neural network in the study is obtained by integrating c-mean algorithm and Kohonen clustering algorithm. And by automatically adjusting the size of FCM objective function nodes of non-sequential artificial neural network, an innovative student training quality evaluation system based on KOHONEN neural network is designed. At the same time, taking the students of Class Three and Four of Grade One in the Junior Middle School of Xinghua Middle School in Shenyang City, Liaoning Province as the research objects, the training quality of students in two classes is evaluated, which are basically the same under the control variable method and the control experiment method by using the KOHONEN neural network training quality evaluation system designed. The experiment mainly includes the following aspects: (1) preparation for the experiment; (2) a test before the experiment; (3) training before the experiment; (4) implementation of the experiment; (5) a test after the experiment is completed; the test results of homogeneity of variance between the number of test results and the expected evaluation data of the evaluation system are as follows: As the result is much larger than 0.10, it can be concluded that the expected results of model evaluation are basically consistent with the results of the test after the experiment is completed, which confirms that the evaluation results obtained by using the evaluation system based on KOHONEN neural network have high accuracy. However, the design of this system also has certain defects. The top-level structure design of the evaluation system based on KOHONEN neural network is more complicated, which is not conducive to the popularization and application of the model. Therefore, in the future research, the defects in this aspect will be improved.

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Human Subjects Approval Statement

This paper did not include human subjects.

Conflict of Interest Disclosure Statement

None declared.

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