

Research on the Construction and Application of Risk Prediction Model for University Management Students with Learning Difficulties Based on Machine Learning

Yunxia Huang *

Zhanjiang University of Science and Technology, Zhanjiang, Guangdong, 524000, China

* Corresponding author Email: 313474657@qq.com

Abstract: The state has proposed to promote educational equity and the all-round development of students, but the existence of "students with learning difficulties" is contrary to the requirements of all-round development. The construction of a risk prediction model for students with learning difficulties is a teaching mode that can help students identify learning difficulties in advance, stimulate their interest in learning, reduce cognitive load, improve learning efficiency, and cultivate students' abilities and core literacy. This paper takes strengthening the education of the management major in universities as the core, and aims to promote educational equity and facilitate the all-round development of "students with learning difficulties". It proposes the construction and application research of a risk prediction model for students with learning difficulties in university management majors based on machine learning. In response to the problem of slow convergence speed in traditional machine learning This paper proposes an analysis model for the causes of learning difficulties among college management students based on the conjugate gradient method in machine learning, in order to predict the formation reasons of the difficulties of college management students. The factor quantification adopts the fuzzy comprehensive evaluation method. The experimental simulation results show that the system model shortens the training time, and the error between the predicted value and the actual value is zero. This model can be applied to the learning difficulties of English in higher vocational colleges Analysis and prediction of causes.

Keywords: Machine Learning; Intelligent Connected Vehicle Test Field Test Scenario; Fuzzy Comprehensive Evaluation Model; Virtual Simulation.

1. Research Background

The university management major proposes to strengthen quality-oriented education, with the all-round development of students as the core, and promote the fair development of education. Some students, due to personal reasons, subject characteristics, family and other factors, have lost interest in learning or even developed a dislike for it, seriously deviating from the original intention and requirements of the new curriculum reform [1]. Therefore, educators need to earnestly implement the concepts of the new curriculum reform, in accordance with the requirements of the curriculum reform for university management majors, fully demonstrate the students' dominant position, help students change their current situation of disliking learning, and promote the all-round development of students.

As a university discipline, the major of university management plays a significant role in social development and the cultivation of students' abilities. In the process of learning chemical knowledge, students can exercise their practical operation ability, cultivate logical thinking ability, and stimulate innovation and imagination. However, the chemistry discipline has a large number of knowledge points that are disorganized and disorganized. Some of the knowledge points are abstract and difficult to understand, which leads to some students losing interest in learning and their grades plummeting. Eventually, they become students with learning difficulties in the management major of universities [2]. The formation of students with learning difficulties in university management majors is contrary to the requirements of the new curriculum reform. Therefore, how

to help these students with learning difficulties stimulate their interest in learning and improve their learning efficiency has also become a key issue of concern for many scholars and front-line teachers.

The construction of a risk prediction model for students with learning difficulties, as an intuitive and modern teaching method, can make abstract knowledge explicit, helping students more easily overcome teaching difficulties, sort out and summarize knowledge, and form a complete knowledge system. At the same time, it can also stimulate students' interest in learning and teach them to study using scientific methods. Therefore, visualization has been widely applied in front-line teaching and achieved good results. However, there is a considerable lack of research on how to apply visualization in teaching to help students with learning difficulties improve their learning efficiency. At the same time, this is also worthy of study by a large number of scholars. Important arrangements have been made for the educational reform of the management major in Shenzhen University. The management major in Shenzhen University aims to cultivate advanced skilled talents [3]. Mastering certain management skills is a compulsory course for every student majoring in management in Shenzhen University. However, due to various reasons, most students majoring in management in Shenzhen University give up their studies and thus become students with difficulties in learning management. Based on the above situation, it is necessary to use an algorithm to analyze and predict the causes of the formation of students with learning difficulties in university management majors, so as to provide targeted solutions in the future management studies of university management major students and reduce

the number of students with learning difficulties. Machine learning can achieve the function of any complex nonlinear mapping and is suitable for solving problems with complex internal mechanisms. The conjugate gradient method has the advantages of fast convergence speed and fast computing speed. This paper applies the conjugate gradient method of BP neural network to the prediction and analysis of the causes of learning difficulties among students majoring in university management.

2. Research Status

Research on "learning disability" abroad started earlier. A search on China National Knowledge Infrastructure (CNKI) with the keyword "learning disability" yielded 16,609 academic papers. Among them, the earliest paper was published in 1932, which indicates that academic research on the type of "learning difficulties" abroad started early and was in-depth. The term "student with learning difficulties" originated from the American medical educator Morgan, who discovered "word blindness" in 1896 [4]. He conducted in-depth research on this symptom from a medical perspective, determined the concept of learning difficulties, and defined those children who were unable to distinguish the meanings of words as "problem students". Most of the research during this period suggested that the main cause of students' learning difficulties was brain loss.

With the rapid development of theoretical research in education and psychology, some scholars in the United States have changed their research perspectives and are conducting studies on students whose learning difficulties are caused by non-intellectual factors from the perspectives of education and psychology [5]. This concept has drawn the attention and emphasis of a large number of scholars, and many scholars have made significant breakthroughs in related research directions [6]. Japanese educator Renhiko Kitao believes that the causes of students' learning difficulties are not limited to schools but encompass multiple factors. He proposed the "three-level theory", dividing the causes of students' learning difficulties into three levels. The first level is the direct level,

which refers to the improper educational methods used by teachers in the teaching process and the improper learning methods of students, etc. The second level is the psychological level, which refers to students' lack of self-control, interest in learning, and motivation during the learning process, etc. [6] The third level refers to environmental factors, which include the adverse effects that society, schools, classes, families and other factors have on students. Although there are many factors that cause students' learning difficulties, the most important reason is still teaching. In the 1980s, the American psychologist Gardner proposed the "Theory of multiple intelligences". He believes that human intelligence is not a single ability but a combination of multiple abilities. The different combinations of linguistic intelligence, natural intelligence, spatial intelligence, musical intelligence, intrapersonal intelligence, motor intelligence, interpersonal intelligence, and logical-mathematical intelligence demonstrate the intelligence among individuals. Therefore, there is no obvious intellectual difference between students with learning difficulties and those with excellent academic performance. The disparity in academic achievements is caused by external factors.

Machine learning is a multi-layer neural network model that adopts the BP algorithm. It consists of an input layer, an intermediate layer (hidden layer), and an output layer, and the intermediate layer can be one or more layers [7][11]. The learning process of the BP neural network consists of two parts: forward propagation and backward propagation. When propagating forward, information is processed from the input layer to the output layer through the intermediate layer, and the state of neurons in each layer only affects the state of neurons in the next layer. If the required output is not obtained at the output layer, it is transmitted to backpropagation and the error signal is returned along the original neuron connection path [8][12]. During the return process, the weights of neurons in each layer are modified one by one. Repeat this process iteratively until the error signal is within the allowable range. The machine learning model is shown in Figure 1.

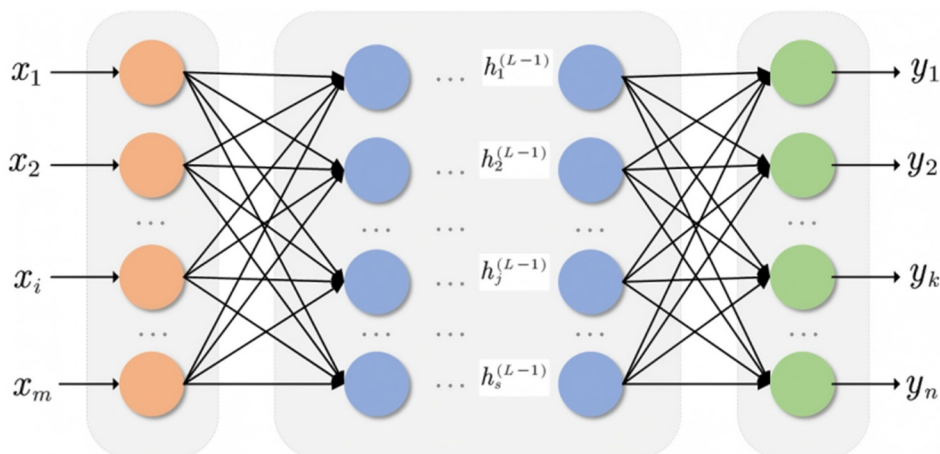


Figure 1. BP neural Network model

The Ploak-Ribiere conjugate gradient method is an algorithm that determines the conjugate direction by using the gradient of the objective function. That is, only the gradients of adjacent two points need to be used to construct a conjugate direction and perform iterations. The conjugate gradient method is a technique that lies between the steepness-descent method and the Newton method. It utilizes first-order

derivative information [9], overcomes the slow convergence drawback of the steepness-descent method, and also avoids the disadvantage of the Newton method that requires storing and calculating the Hesse matrix and inverting it.

3. Establishment of a Model for the Causes of English Learning Difficulties in Higher Vocational Colleges

3.1. Data Analysis and Processing

Students with academic difficulties in university management refer to those who have normal intelligence but encounter difficulties in their studies of management, resulting in lagging management grades. The factors that affect the difficulty of management learning for university management major students can be divided into students' own factors, school factors and family factors. Among them, the white body factors include the foundation of management, the motivation for learning management, the interest in learning management, and the habits and methods of learning management. School factors include teachers' attitudes, teaching methods, the learning environment for management, and textbook factors. Family factors include family economic conditions, family situations and parents' expectations. Among the factors influencing the learning difficulties of students majoring in management in universities, some can be directly quantified [10]. For instance, the foundation in management among personal factors can be analyzed based on the scores of liberal arts in the college entrance examination. However, some influencing factors are qualitative and difficult to quantify, such as the learning attitude, interest, learning habits and methods in management among personal factors, as well as school and family factors. Therefore, the multi-factor fuzzy comprehensive evaluation method is utilized to quantitatively process the qualitative indicators. Here, taking the school factor as an example, we introduce how to quantify the qualitative indicators of the school factor. School factors include four aspects: teachers' attitudes, teachers' teaching methods, the learning environment for management, and textbook factors.

Let the school factor set U be:

(1) $U = \{u(\text{teacher's attitude}), u(\text{teacher's teaching method}), u_3(\text{English learning environment}), u(\text{textbook factors})\}$

(2) The evaluation set V of school factors is:

$V = \{u(\text{excellent}), v(\text{good}), v(\text{medium}), v(\text{pass}), v; (\text{Fail})\}$.

(3) the corresponding score range for different comments: excellent = [90|100], good = [= 80, living), (70), pass = [60; seven), fail = [0, 60).

Taking the management teaching of a certain teacher in a certain school as an example, experts have made a single-factor evaluation vector:

$R_1 = [0.1, 0.4, 0.5, 0 \text{ cutflower production potentials.}]$

$R_2 = [0.2, 0.3, 0.3, 0.1, 0]$

$R_3 = [0.2, 0.5, 0.3, 0 \text{ cutflower production potentials.}]$

$R_4 = [0.4, 0.3, 0.3, 0.07]$. The evaluation matrix composed of R_1, R_2, R_3 , and R_4 is

$R = [0.1, 0.4, 0.5, 0.2, 0.3, 0.3, 0.1, 0.2, 0.5, 0.3, 0.4, 0.3, 0.3, 0, 0]$ to school, the four factors of factor set U give weight $X = [0.2, 0.4, 0.2, 0.2]$

(4) The overall comprehensive evaluation of the school factor set U is $Y = X \cdot R = [0.22, 0.36, 0.34, 0.04, 0]$. Owned by one becomes $Y = [0.229, 0.375, 0.354, 0.042, 0]$. Based on this, the school factor score corresponding to this English teacher can be calculated as $[0.229 \times (100+90)/2 + 0.375 \times (90+80)/2 + 0.354 \times (80+70)/2 + 0.042 \times (70+60)/2] = [21.755 + 31.875 + 26.55 + 2.737 = 82.91]$.

By analogy, the school factor scores corresponding to other

English teachers can be calculated.

The family factor set U is set to consist of three factors: family economic conditions, family status, and parents' expectations. The evaluation set is also set to five grades: excellent, good, medium, pass, and fail. The calculation method of family factors is similar to that of school factors. Among the self-factors, there are both qualitative and quantitative indicators. The calculation method of the qualitative indicators in the self-factors is similar to that of the school factors. The total self-factors are taken as the average of the qualitative and quantitative indicators. The data of various factors affecting students with learning difficulties in university management majors are listed in Table 1 below.

Table 1. shows the data of various factors affecting students with learning difficulties in university management majors

Serial number	Self factor	School factor	Family factor	Whether it is a poor student of management
1	80	90	80	NO
2	20	85	50	YES
3	30	80	60	YES
4	85	85	70	YES
5	75	70	60	NO
6	40	70	40	NO
7	30	75	80	YES
8	45	80	60	YES
9	55	90	50	YES
10	10	80	80	NO
11	80	85	10	YES
12	50	85	20	YES
13	40	80	30	YES
14	70	85	40	NO
15	80	85	80	NO

The value range of the S-excitation function of the BP neural network model is all in [0,1], but all the factor data in Table 1 are integers greater than 1. Therefore, the integer data in Table 1 needs to be normalized. The normalization formula is:

$$Y_i = \frac{Y_i - Y_{\min}}{Y_{\max} - Y_{\min}} \quad (1)$$

Table 2. normalized the data in Table 1

Serial number	Self factor	School factor	Family factor	Whether it is a poor student of management
1	0.933	1	1	0
2	0.133	0.75	0.571	1
3	0.267	0.5	0.714	1
4	1	0.75	0.857	0
5	0.867	0	0.714	0
6	0.4	0	0.429	1
7	0.267	0.25	1	1
8	0.467	0.5	0.714	1
9	0.6	1	0.571	0
10	0	0.5	1	1
11	0.933	0.75	0	0
12	0.533	0.75	0.142	1
13	0.4	0.5	0.286	1
14	0.8	0.75	0.429	0
15	0.933	0.75	1	0

3.2. Design of Prediction Model Based on BP Neural Network

The BP algorithm iteratively calculates the error and updates the weights and biases through the backpropagation formula. The selection of the loss function affects the accuracy and convergence speed of the network. Commonly used loss functions include mean square error (MSE) and cross-entropy. During the training process, timely adjustments to the learning rate and batch size are usually set to enhance training efficiency and model performance. In addition, to enhance the generalization ability of the type, the

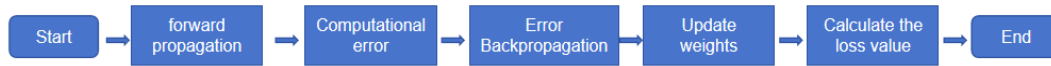


Figure 2. BP learning algorithm process

In the algorithm implementation process of BP neural network, two propagation processes need to be gone through, namely forward propagation and backward propagation. When propagating forward, the input information starts from the input layer, undergoes nonlinear transformation through the hidden layer, and is finally output through the output layer. Backpropagation, on the other hand, passes the errors of the output layer back to the network layer by layer. During this process, the errors of each unit in the hidden layer need to be constantly calculated, and these errors are used to correct the weights of the previous layer. The following takes a typical three-layer BP neural network as an example to demonstrate its computational steps. Suppose there are m neurons in the input layer, n neurons in the hidden layer, and p neurons in the output layer. The specific implementation steps are as follows:

1) The calculation formula for the input value IH_j of the J TH node in the hidden layer is shown in Equation (2) :

$$IH_j = \sum_{i=1}^m x_i \times w_{ij} + b_1 \quad (2)$$

2) Calculate the output value of the hidden layer node. The calculation formula for the output value OH of the J TH node in the hidden layer is shown in Equation (3)

$$OH_j = f(IH_j) \quad (3)$$

Among them, $f(x)$ is the hidden layer activation function such as sigmoid, tanh, relu, etc.

3) Calculate the input value of the K TH node in the output layer. The calculation formula for the input value IO_k of the K TH node in the output layer is shown in Equation (4)

$$IO_k = \sum_{j=1}^n OH_j \times w_{jk} + b_2 \quad (4)$$

4) Among them, j represents the J TH neuron node of the hidden layer.

5) Calculate the output values of the output layer nodes. The calculation formula for the output value OO_k of the K TH node in the output layer is shown in Equation (5):

$$OO_k = f(IO_k) \quad (5)$$

6) Calculation error

Error reflects the difference between the predicted value and the true value of the output. The smaller the error, the closer the predicted value is to the true value, and the higher the prediction accuracy of the model. Conversely, the smaller

best parameter configuration can be selected through cross-validation. Meanwhile, to prevent overfitting, regularization methods such as L2 regularization and Dropout regularization can be adopted.

The BP learning algorithm is the core training algorithm of the backpropagation neural network, and its main function is to optimize the network weights and biases by learning sample data. This algorithm adopts the gradient descent method, with the goal of minimizing the loss function such as the mean square error. The algorithm flow of the BP learning algorithm is shown in Figure 2.

the error, the higher the prediction accuracy. The ultimate goal of the BP neural network is to minimize the loss value, that is, to achieve the minimum value of the loss function. If the loss value is not within the given range, backpropagation is carried out to adjust the weight value and bias value, ultimately minimizing the loss function: MSE (Mean Square Error) represents the average square error between the predicted value and the true value, which can reflect the accuracy of the model's prediction. Additionally, the MSE function is a differentiable function, which is very important for gradient calculation and optimization algorithms. Therefore, it is very appropriate to choose the MSE function as the loss function to calculate the error between the predicted value and the true value. The calculation formula of the loss function is shown in Equation (6):

$$E = \frac{1}{n} \sum_{i=1}^n (Y_i - \hat{Y}_i)^2 \quad (6)$$

7) Among them, i represents the neuron nodes of the output layer, Y_i represents the true value of the i -th neuron, and \hat{Y}_i is the predicted value output by the i -th neuron.

8) Update of weight values and bias values from the output layer to the hidden layer. To make the predicted values approach the true values, we need to minimize the loss function, which requires us to constantly adjust the weight values and bias values. If we want to know how much the weight value w_{jk} from the output layer to the hidden layer affects the overall error, we can calculate it by taking the partial derivative of the overall error with respect to w_{jk} . This process requires the use of the chain rule of partial derivatives to determine the partial derivative of the overall error with respect to w_{jk} . The formula for calculating the weight value using the chain rule of partial derivatives is shown in Equation (7)

$$\frac{\partial E}{\partial w_{jk}} = \frac{\partial E}{\partial OO_k} * \frac{\partial OO_k}{\partial IO_k} * \frac{\partial IO_k}{\partial w_{jk}} \quad (7)$$

After calculating the partial derivative of the error with respect to the weight value w_{jk} , the weight value can be updated. The calculation formula for updating the weight value is shown in Equation (8) :

$$w_{jk}^+ = w_{jk} - \eta * \frac{\partial E}{\partial w_{jk}} \quad (8)$$

Among them, η is the learning rate, usually taking a value of 0.5. The update of the bias value from the output layer to the hidden layer and the weight value are the same. First, the partial derivative of the loss function with respect to the bias value b is obtained, and then the bias value is updated based on the partial derivative and the learning rate. The calculation formula for the partial derivative with respect to the offset value is shown in Equation (9) :

$$\frac{\partial E}{\partial b_2} = \frac{\partial E}{\partial O O_k} * \frac{\partial O O_k}{\partial I O_k} * \frac{\partial I O_k}{\partial b_2} \quad (9)$$

The calculation formula for updating the bias value is shown in Equation (10) as follows:

$$b_2^+ = b_2 - \eta * \frac{\partial E}{\partial b_2} \quad (10)$$

9) The update of the weight values and bias values from the hidden layer to the input layer is the same as that from the output layer to the hidden layer. First, obtain the partial derivative of the loss function with respect to the weight value w , and then update the weight value based on the partial derivative and the learning rate. The calculation formula for the partial derivative of the weight values from the hidden layer to the input layer is shown in Equation (11):

$$\frac{\partial E}{\partial w_{ij}} = \frac{\partial E}{\partial O H_j} * \frac{\partial O H_j}{\partial I H_j} * \frac{\partial I H_j}{\partial w_{ij}} \quad (11)$$

The calculation formula for the weight value update is shown in Equation (12) as follows:

$$w_{ij}^+ = w_{ij} - \eta * \frac{\partial E}{\partial w_{ij}} \quad (12)$$

The calculation formula for the partial derivative of the offset value from the hidden layer to the input layer is shown in Equation (13):

$$\frac{\partial E}{\partial b_1} = \frac{\partial E}{\partial O H_j} * \frac{\partial O H_j}{\partial I H_j} * \frac{\partial I H_j}{\partial b_1} \quad (13)$$

The calculation formula for the offset value update is shown in Equation (14) as follows:

$$b_1^+ = b_1 - \eta * \frac{\partial E}{\partial b_1} \quad (14)$$

10) Perform iterative calculations based on the new weight values and bias values until the total output error is less than the set threshold

The above are the design steps of the model. Now, through the analysis of the causes of learning difficulties among students majoring in university management in colleges and universities, a three-layer BP network is used to establish an analysis model for the causes of learning difficulties among students majoring in university management. Through the analysis of the data in Table 1, the BP neural network is applied to find out the mapping relationship between various factors contributing to the formation of learning difficulties among students majoring in university management and learning difficulties. The various factors (such as physical factors, school factors, and family factors) that cause learning difficulties among students majoring in university management as shown in Table 2 are taken as the input values

of the neural network, and whether they have learning difficulties or not is taken as the output value of the neural network. Twelve samples were randomly selected as training samples, and the remaining three samples were used as test samples.

Based on the above analysis, the number of neurons in the input layer of machine learning is 3, and the number of neurons in the output layer is 1. If the number of neurons in the hidden layer is too large or too small, it may lead to significant errors and needs to be continuously adjusted through actual training. After multiple trainings, it is more appropriate to set the number of neurons in the hidden layer to 7, then the network topology structure is 3x7x1.

Use the dedicated function `newff()` provided by the MATLAB tool box `NNbox` for establishing neural networks. This function determines the number of network layers, the number of neurons in each layer, the transfer function and the training algorithm. In the command window of MATLAB, input the vector p and the target vector t , establish the BP neural network model using `newff()`, then set the network parameters, and finally start the network training. The "MATLAB" command is as follows.

```
>>p=[0.933,0.133,0.267,1.00,0.867,0.40,0.267,0.467,0.6,0.933,0.533;
1,0.75,0.5,0.75,0,0,0.25,0.5,1,0.5,0.75,0.75;
1,0.571,0.714,0.857,0.714,0.429,1,0.714,0.571,1,0,0.142];
>>t=[0,1,1,0,0,1,1,1,0,1,0,1;
>>net=newff(minmax(p);
('tansig,logsig),traincgp);
>>net.trainparam.show=100;
>>net.trainparam.lr=0.05;
>>net.trainparam.lr_inc=1.05 ;
>>>net.trainparam.epochs=1500;
>>>net.trainparam.goal=1e-8;
>>[net,tr]=train(net,p,t);
```

As can be seen from Figure 3, after 20 steps of training, convergence was achieved, reaching the performance of the network.

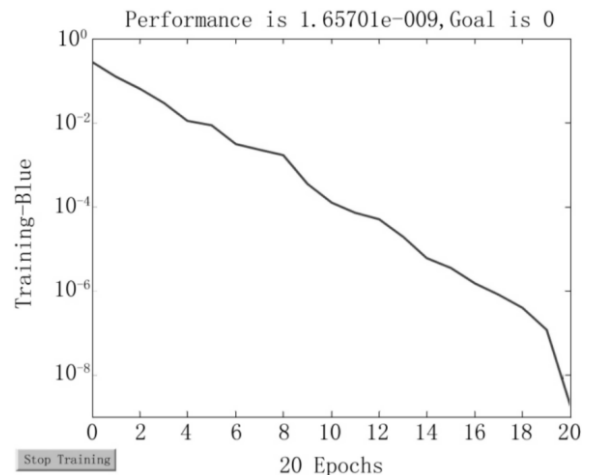


Figure 3. Convergence of machine learning training

3.3. Model Testing and Application

Now, the trained network will be used for testing, and the remaining 3 samples will be extracted as the test input samples of the network for testing. The MATLAB command is as follows:

```
P1 = [0.4, 0.8, 0.933, 0.5, 0.75, 0.75, 0.286, 0.429, 1];
a=sim(net,P)
```

The test results are shown in Figure 3. It can be seen from

the test results that the error between the actual value and the predicted value is 0. Therefore, after training, this network can be used to predict and analyze the causes of learning difficulties among students majoring in management in universities. By applying the trained machine learning and taking the normalized indicators of various management students in a certain university as [0.4,0.8,0.9], the input samples of the neural network are:

Test = [0.4, 1,1,1,0.8, 1,1,1,0.9]

When only one factor in the test sample changes, the influence on the causes of learning difficulties in university management majors is obtained through network training :A-sim(net,test) to obtain the simulation results:

A=0.1073 0.00000.0000;

From the simulation results, it can be predicted that the main reason for the student's difficulty in learning management is his own factors, while the influence of school and family factors is almost non-existent. Therefore, he can start from himself, improve the motivation for learning management, and enhance the interest in learning, etc.

4. Conclusion

Machine learning models can be used to analyze the causes of the formation of students with learning difficulties in university management majors, thereby providing targeted solutions and reducing the number of such students. This paper analyzes various factors contributing to the formation of students with learning difficulties in university management majors through machine learning. Firstly, qualitative indicators are quantified and normalized by the fuzzy comprehensive evaluation method. The result data is used as the input sample for machine learning, and then a network model is established with the simulation software MATLAB. Through simulation tests, the error between the actual value and the predicted value is zero. Therefore, it can be used as a tool to analyze the causes of learning difficulties among students majoring in management in universities, and it can also be used to analyze the causes of learning difficulties among students majoring in management in universities.

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References

- [1] Jin, X. Q., Jiang, Q., & Ma, Z. Q., et al. (2023). Research on intelligent diagnosis model for college students with learning difficulties in the digital intelligence era. *Modern Educational Technology*, 33(11), 47–56.
- [2] Li, M. R. (2024). Research on the current situation and improvement of learning outcomes of underachieving students in higher vocational colleges in the digital intelligence era. *Journal of Hubei Open University*, 44(5), 33–37.
- [3] Li, Y. (2022). Research on the transformation countermeasures of students with learning difficulties in college English teaching in traditional Chinese medicine colleges from the perspective of "student-centeredness". *Journal of Chengdu University of Traditional Chinese Medicine (Educational Science Edition)*, 24(4), 39–41, 70.
- [4] Lin, X. Y. (2024). Action research on the transformation of junior high school students with English learning difficulties based on the PERMA model [Master's thesis]. Guangzhou University. <https://kns.cnki.net/kcms2/article/abstract?v=10.27040/d.cnki.ggzdu.2024.000533>.
- [5] Zheng, P. (2024). Research on visual teaching strategies for improving the learning efficiency of students with learning difficulties [Master's thesis]. Yunnan Normal University. <https://kns.cnki.net/kcms2/article/abstract?v=10.27459/d.cnki.gynfc.2024.000507>.
- [6] Chen, Q. (2024). A case study on the motivation development of top and struggling students in the reading process of junior high school English reading classroom from the perspective of complex dynamic systems theory [Master's thesis]. Central China Normal University. <https://kns.cnki.net/kcms2/article/abstract?v=10.27159/d.cnki.gzhzs.2024.002481>.
- [7] Li, G. S., Gao, T. G., Liu, X., et al. (2018). Research on prediction of students with learning difficulties based on extreme learning machine algorithm. *Journal of Electrical and Electronic Teaching*, 40(2), 69–75.
- [8] Cui, X. C., Wang, J., Cui, X. M., et al. (2018). Attribution analysis of college students with learning difficulties based on ID3 algorithm. *Journal of Electrical and Electronic Teaching*, 40(2), 69–75.
- [9] Guo, Q. C. (2024). Structural design and optimization of copper-based composites based on machine learning and multi-objective optimization [Master's thesis]. Xi'an University of Science and Technology. <https://kns.cnki.net/kcms2/article/abstract?v=10.27398/d.cnki.gxalu.2024.000820>.
- [10] Deng, J., Chen, K. Y., Liu, S. Y., et al. (2025). Carbon emission prediction method for vessels on the Yangtze River trunk line based on MPA-BP. *Journal of Wuhan University of Technology (Traffic Science and Engineering Edition)*. Advance online publication. <https://kns.cnki.net/kcms/detail/detail.aspx?dbcode=CJFD&dbname=CJFDLAST2025&filename=WHJT20250325002>.
- [11] Chen, X. C., Ji, Z. R., Zheng, Y., et al. (2025). DBO-machine learning-based activity guide vane abrasion prediction model. *Journal of Huazhong University of Science and Technology (Natural Science Edition)*. Advance online publication. <https://doi.org/10.13245/j.hust.250405>.
- [12] Wu, Y. M., Zhang, C. L., & Zhang, H. X. (2025). Slope deformation prediction research based on hippopotamus algorithm optimized machine learning model. *Water Resources and Hydropower Technology (Bilingual Edition)*. Advance online publication. <https://kns.cnki.net/kcms/detail/10.1746.TV.20250315.1157.006.html>.