Mathematical Biosciences and Engineering

MBE, 20(8): 15120–15134.
DOI: 10.3934/mbe.2023677
Received: 08 February 2023
Revised: 12 May 2023
Accepted: 24 May 2023
Published: 17 July 2023

http://www.aimspress.com/journal/MBE

Research article

An intelligent decision support approach for quantified assessment of innovation ability via an improved BP neural network

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Abstract: In today's competitive and changing social environment, innovation and entrepreneurial ability have become important factors for the successful development of college students. However, relying solely on traditional evaluation methods and indicators cannot comprehensively and accurately evaluate the innovation and entrepreneurial potential and ability of college students. Therefore, developing a comprehensive evaluation model is urgently needed. To address this issue, this article introduces machine learning methods to explore the learning ability of subjective evaluation processes and proposes an intelligent decision support method for quantitatively evaluating innovation capabilities using an improved BP (Back Propagation) neural network. This article first introduces the current research status of evaluating the innovation and entrepreneurship ability of college students, and based on previous research, it has been found that inconsistent evaluation standards are one of the important issues at present. Then, based on different BP models and combined with the actual situation of college student innovation and entrepreneurship evaluation, we selected an appropriate input layer setting for the BP neural network and improved the setting of the middle layer (hidden layer). The identification of output nodes was also optimized by combining the current situation. Subsequently, the conversion function, initial value and threshold were determined. Finally, evaluation indicators were determined and an improved BP model was established which was validated using examples. The research results indicate that the improved BP neural network model has a low error rate, strong generalization ability and ideal prediction effect which can be effectively used to analyze problems related to intelligent evaluation of innovation ability.

Keywords: intelligent decision support; quantified assessment; BP neural network; deep learning

1. Introduction

In today's competitive and changing social environment, innovation and entrepreneurial ability have become important factors for the successful development of college students [1]. However, the current indicator system is not scientific enough and the evaluation standards are not unified and flexible. As the cornerstone of cultivating innovative and entrepreneurial talents, universities are striving to integrate innovation and entrepreneurship education into the curriculum system to cultivate students' innovative thinking and entrepreneurial abilities [2,3]. However, relying solely on traditional evaluation methods and indicators cannot comprehensively and accurately evaluate the innovation and entrepreneurship potential and abilities of college students. Therefore, developing a comprehensive evaluation model is urgently needed.

This study aims to propose a combined evaluation model for college students' innovation and entrepreneurship abilities based on an improved BP neural network, in order to comprehensively evaluate the innovation and entrepreneurship abilities of college students. The traditional BP neural network model has been widely applied in various fields, but it has certain limitations in handling the relationships between complex features and improving accuracy [4,5]. Therefore, we will improve the BP neural network to improve its evaluation ability and prediction accuracy.

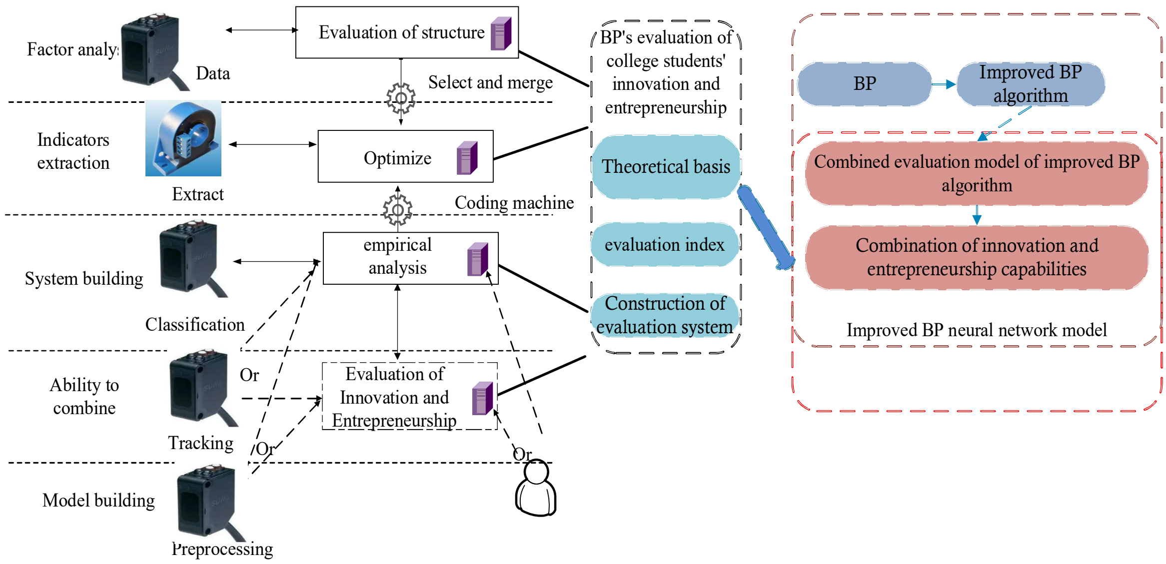


Figure 1. Portfolio evaluation framework of innovation and entrepreneurship capability based on the BP neural network model.

By using an improved BP neural network based composite evaluation model for college students' innovation and entrepreneurship abilities, we can more accurately capture their innovation and entrepreneurship abilities and provide them with targeted development suggestions and training guidance. The application of this evaluation model can promote the growth and development of college students in the field of innovation and entrepreneurship, and enhance their potential for successful innovation and entrepreneurship [6,7].

The evaluation indicators for innovative education need to reflect the business characteristics of teachers' innovative work ability, while real-time understanding of teaching and teaching impact, with students and teaching environment factors as the main indicators [8,9]. This includes the number of courses, the impact of teacher work, and the impact of teaching on entrepreneurship. Social demand is the fundamental measure for evaluating the quality of higher education, and evaluation should be led by society. This paper studies the connotation, characteristics and evaluation model of innovative education in Research university by using improved BP and neural network methods.

2. Related works

The evaluation of college students' innovation and entrepreneurship ability is of great significance for cultivating high-quality innovation and entrepreneurship talents. However, traditional evaluation methods are often too single or one-sided, making it difficult to comprehensively and objectively evaluate the comprehensive abilities of college students. Therefore, researchers have begun to explore innovation and entrepreneurship capability evaluation models based on neural networks with BP neural network being widely used as a commonly used model in this field.

There are currently some scholars at home and abroad who have conducted in-depth exploration on the combination evaluation model of college students' innovation and entrepreneurship abilities based on improved BP neural networks. Tkáč et al. [10] proposed an evaluation model based on an improved BP neural network. By establishing appropriate network structures for input, hidden and output layers and combining evaluation indicators for college students' innovation and entrepreneurship abilities, a comprehensive evaluation of college students' innovation and entrepreneurship abilities was achieved. Through empirical analysis, researchers have found that this model has good accuracy and practicality in evaluating the innovation and entrepreneurship ability of college students. Zhang et al. [11] proposed an improved algorithm to address the shortcomings of BP neural networks in evaluating the innovation and entrepreneurship abilities of college students. They optimized the training process of BP neural network by introducing weight adaptive mechanism and activation function adjustment strategy and applied it to the evaluation of college students' innovation and entrepreneurship ability. The results indicate that the improved BP neural network has achieved better results in evaluating the innovation and entrepreneurship abilities of college students. Tien et al. [12] proposed a model for evaluating the innovation and entrepreneurship ability of college students based on an improved BP neural network. They summarized a large number of quality indicators and evaluated them using an improved BP neural network model, obtaining the level of innovation and entrepreneurship ability under different conditions. Collatta et al. [13] proposed an innovation and entrepreneurship capability evaluation model based on BP neural network and validated it in actual samples. The research results indicate that this model can accurately evaluate the innovation and entrepreneurship abilities of college students and conduct detailed analysis on them. Rikalovic et al. [14] proposed an improved BP neural network model that combines fuzzy mathematics theory and entropy weight method to evaluate the innovation and entrepreneurship ability of college students. The research results show that this model can better reflect the multidimensional innovation and entrepreneurship abilities of college students and improve the accuracy of evaluation. Hameed [15] studied the evaluation of innovation and entrepreneurship abilities of college students based on an improved BP neural network. The results show that there is a certain positive correlation between innovation ability and entrepreneurial ability and this relationship is influenced by creative thinking and teamwork. Alabi et al. [16] used an improved BP neural network to evaluate the innovation and entrepreneurship ability of college students from multiple perspectives. Their research results showed that innovation awareness, entrepreneurship ability and team collaboration are important factors affecting college students' innovation and entrepreneurship ability and there are complex correlations between these factors.

3. Improve model establishment

Research and evaluation systems are characterized by fragmentation and lack of systematization. Most researchers in China construct evaluation index systems based on self-subjective design directly and there is still much room for improvement in the systematic, scientific and practical aspects of evaluation research. In theoretical research, most focus on subjective evaluation and theoretical evaluation and lack of procedural evaluation design [17,18]. Western education philosophy, curriculum, teacher structure, teaching process, resource integration, evaluation system, etc. focuses on exploring models, the guarantee system, current problems and the evaluation system. China has yet to formulate a rating standard that meets its own national conditions. Most of the teaching contents of entrepreneurship education in colleges and universities in China adhere to the simple division of teaching contents of innovative entrepreneurship education. Compared with Chinese universities, the educational philosophy and goals of American universities improve efficiency [19]. Therefore, we should set out from the long-term goal, gradually abandon the utilitarianism concept, change the innovative curriculum goal, improve students' entrepreneurial quality in an all-around way and cultivate talents. The factors such as the entrepreneurial environment, regional culture, entrepreneurial practice and characteristics of schools are taken into account. Therefore, from the perspective of BP neural network model evaluation, this paper makes a scientific evaluation which provides a new research direction for the evaluation of innovation.

3.1. Input layer settings

The input layer of the combined evaluation model for college students' innovation and entrepreneurship ability based on improved BP neural network is to comprehensively evaluate the innovation and entrepreneurship ability of college students by considering multiple factors. Innovation and entrepreneurship ability is a comprehensive ability that is not only related to academic performance, but also to personal practical experience and personal characteristics [20]. Therefore, combining multiple factors to evaluate can provide a more comprehensive understanding of college students' innovation and entrepreneurship abilities. Different students have different characteristics and backgrounds, and relying solely on a single indicator cannot comprehensively evaluate their innovation and entrepreneurship abilities. By comprehensively considering various factors, the personalized innovation and entrepreneurship potential of college students can be more accurately evaluated.

The improved BP neural network needs to automatically adjust the weight and bias through the Backpropagation to approach the target output value [21]. By improving the BP neural network or adopting more advanced neural network models, it is possible to better cope with the complex relationships between features and improve the accuracy and robustness of the evaluation model. The data in the input layer mainly includes students' personal information, academic achievements and innovation and entrepreneurship experiences. By using the above information as the input layer of the BP neural network model, these different features can be comprehensively considered and combined with machine learning algorithms and large-scale data training, a more accurate and comprehensive combination evaluation model for evaluating the innovation and entrepreneurship ability of college students has been established. This evaluation model can provide targeted guidance and training suggestions for college students, promoting the improvement of their innovation and entrepreneurship abilities.

3.2. Identify nodes in the intermediate layer (hidden layer)

The L layer is defined as a layer, and there is no uniform standard to define the number of neurons b:

$$L = \sqrt{k + l} + b \tag{3.1}$$

3.3. Output node identification

In order to comprehensively evaluate the innovation and entrepreneurship abilities of college students, we need to evaluate them from different dimensions. The setting of output nodes can help us comprehensively analyze and judge different indicators of innovation and entrepreneurship capabilities. By setting the output nodes, we can provide specific evaluation results and feedback information for each college student which helps them understand their strengths and weaknesses, and develop personalized innovation and entrepreneurship development strategies. The improved BP neural network model can obtain weights and bias parameters through backpropagation training and realize the prediction and evaluation of innovation and entrepreneurship capability [22]. By reasonably designing the setting of output nodes, the innovation and entrepreneurship abilities of college students can be more accurately captured and corresponding evaluation results can be output.

Output nodes can include indicators to measure college students' innovation ability such as the evaluation results of creativity generation ability, problem-solving ability, innovation management and leadership; The output nodes can include indicators to measure the entrepreneurial ability of college students such as market insight, business model design, resource integration and risk management evaluation results; The output node can also provide a comprehensive evaluation output which comprehensively considers multiple indicators of innovation and entrepreneurship ability to obtain the evaluation results of the overall innovation and entrepreneurship ability of college students.

By setting output nodes reasonably, we can obtain a comprehensive evaluation of college students' innovation and entrepreneurship abilities, providing them with targeted development suggestions and training guidance. This evaluation model can promote the growth and development of college students in the field of innovation and entrepreneurship and enhance their potential for successful innovation and entrepreneurship.

3.4. Determine the conversion function

In order to ensure the convergence and learning speed of BP network, this paper improves the traditional BP network model and sets the transformation function of nodes [23,24] in the neural network as follows:

$$F(t)=\frac{1}{1+e^{-t}} \tag{3.2}$$

$$F(t)=\frac{2}{1+e^{-2t}}-1 \tag{3.3}$$

3.5. Set initial weights and thresholds

Effectively shorten the learning time of the BP neural network where N represents the number of neurons in the layer node of the BP model. The experiment shows that the initial value range of the network connection weights and stop values is set to [−1,1]. The scoring steps using the enhanced BP network are shown in Figure 2.

Table 1. Principal components of group table of recognition.

Group	Principal components 1	Principal components 2	Principal components 3	Principal components 4	Principal components 5	Principal components 6	Principal components 7	Y1	Y2
1	24. 022	5. 729	5. 026	3. 318	1 .742	0. 746	0. 522	3 .444	3 .994
2	24. 344	5. 234	4. 962	3. 427	1.892	0. 739	0. 498	2. 792	3 .254
3	23. 918	5. 688	5. 031	3. 446	2.903	0. 862	0. 543	3 .674	4. 006
4	23. 768	5. 639	4. 776	2. 966	1.552	0. 833	0. 459	3 .123	4. 022
5	22. 479	6. 023	4. 953	3. 850	2.709	0. 774	0. 532	3 .096	3 .895
6	23. 538	5. 921	5. 112	3.104	2. 003	0. 822	0. 598	2. 903	3 .644
7	22. 089	6. 137	5. 037	3.004	1.875	0. 776	0.543	3 .785	3 .077
8	23. 417	5. 979	4. 972	3.922	1.864	0. 644	0.456	2. 993	3 .769
9	22. 869	5. 784	5. 015	2. 986	2. 013	0. 724	0.546	3 .704	3.853
10	24. 113	6. 027	4. 979	3. 005	2.764	0. 761	0.623	3 .603	4.314

Because the quality of drivers is directly related to college students' recognition of the school and government. The University and Government Recognition Questionnaire by College Students was subdivided according to the degree of correlation. Highly relevant indicators 2, 5 and 6 were redefined as Y1 and indicators 1, 3, 4 and 7 were redefined as Y2. On this basis, 538 samples were divided into 10 groups for training and the remaining 3 groups for predicting and validating their absolute error values. Table 1 is the main component and recognition group table of influencers. The judgment of hidden layer nodes is the foundation of constructing a perfect BP neural network.

The optimal hidden layer node improves the fault tolerance and generalization ability of the network model.

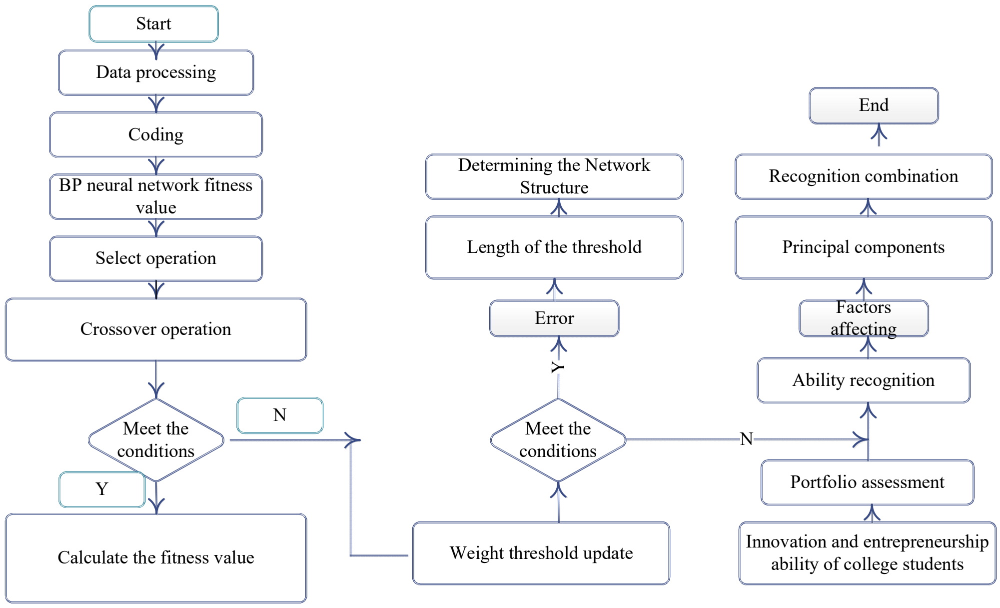


Figure 2. Improved BP neural network model evaluation flowchart.

3.6. Selection of evaluation indicators

At present, scholars usually consider the following points when evaluating students' innovation and entrepreneurship abilities: whether students have participated in innovation and entrepreneurship projects or activities, whether they have entrepreneurial experience, and whether they have achieved innovative results [25–27]. These experiences and achievements can reflect students' innovation and entrepreneurship abilities and practical abilities; Do students have the ability to think independently and solve problems, identify opportunities, expand thinking boundaries and possess the awareness and qualities required for innovation and entrepreneurship; Innovation and entrepreneurship often require teamwork. Whether students have good teamwork, communication and leadership abilities, as well as whether they can effectively coordinate and organize team members; Can students develop reasonable business plans, conduct effective market analysis, market research and competitive analysis and comprehensively evaluate business opportunities; Do students have the ability to access entrepreneurial resources, including financial, social, technological, and other resources, as well as the ability to innovate, including technological innovation and business model innovation. The selection of indicators for evaluating students' innovation and entrepreneurship abilities should not only consider their basic literacy, but also consider the environment they are in and the teaching quality at that time [28]. External factors mainly involve environmental factors, resource factors, etc. Internal factors mainly include higher education entrepreneur's own factors, innovation ability, risk bearing capacity, advanced cognition and agency ability, competitive motivation and degree of autonomy. Evaluating the success of college students' entrepreneurship depends on a combination of the above factors. At present, in the prediction and evaluation index system of technology innovation, one kind is the traditional index system, the other is an index system, USES the overseas advanced countries how to combine the reality of our country's current economic situation, the research work of reference foreign advanced developed countries, establish a set of suitable for the prediction and evaluation index system of technology innovation, this is the first work to do this study, it is an innovation. Overall, the following aspects should be considered:

1.) University setting. It reflects the organizational deployment of research universities to innovative entrepreneurship education including hard environment and soft environment. The former refers to the university's various material security measures in the material aspects such as innovation and start-up funds and infrastructure. The latter refers to science, climate and culture that encourage innovation, entrepreneurship, and fault tolerance.

2.) Among them, teachers' political quality, professional knowledge quality and skill quality are the key points of evaluation; teachers' innovative entrepreneurship skills, that is, teachers' innovation awareness, innovation ability and related scientific research achievements; and teachers' innovative entrepreneurial education ability refers to teachers' ability to master and implement.

3.) Teaching interface. Through the innovative curriculum content and the form, enhances students' innovative and entrepreneurial abilities. Because the weight of indicators has a major influence on the validity of evaluation results, the dependence on indicators is very strong in various evaluation systems. Common methods of index determination methods include compulsory scoring, analytic hierarchy process, sequential analysis and Delphi analysis [29,30]. Aiming at examining the characteristics of the evaluation index system such as hierarchy, diversity and flexibility, this study adopts the literature analysis method to construct the evaluation index system of college student entrepreneurship based on expert interviews and combines the hierarchical analysis method to determine this index weight. The corresponding index system is shown in Table 2.

Table 2. College teaching quality evaluation form (for students).

Level indicators	Weight	Secondary indicators	Weight
Indicators of entrepreneurial ability	0.45	Entrepreneurial ideas	0.17
		Entrepreneurial intention	0.22
		Entrepreneurship preparation	0.21
		Entrepreneurship practice	0.22
		Entrepreneurial quality	0.17
Index of university innovation	0.28	Entrepreneurship education organization support	0.13
		Curriculum	0.25
		Quality	0.25
		Extension activities	0.25
		Reputation	0.19
		The policy environment	0.28
		Family environment	0.24
Environmental indicators for innovation and entrepreneurship	0.27	The achievements of alumni	0.15
		And the school environment	0.18
		Enterprise environment	0.13
		Public opinion	0.17

4. Example of verification

For example, in research-oriented education, effective and innovative evaluation indicators, principles and data collected, crawling on the internet, innovative collection of university students and employment, the MATLAB software is used to provide a toolkit for evaluating the quality of innovation in entrepreneurship education, as follows.

The number of factors affecting the evaluation results is taken as the number. Through the analysis of the index system, there are 48 three-level indicators and 48 input nodes in the evaluation of the quality of the innovative entrepreneurship education system which is compared with the forecast. The prediction errors are shown in Table 3.

Table 3. Prediction error table.

Test sample	C5	C6	C7
Desired output	0.19	0.37	0.83
Network output value	0.176	0.423	0.84
Amount of error	0.035	−0.012	0.034

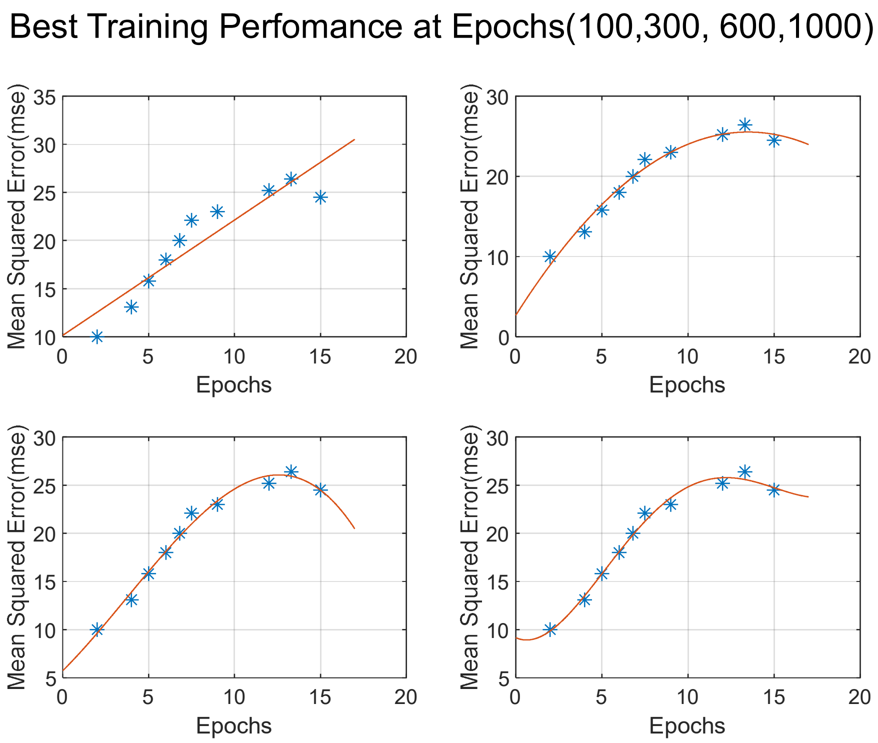


Figure 3. Network training diagram using TrainRP function and TrainLM function.

The performance advantages of different training functions are highlighted in Figures 3–5.

According to the analysis in Figures 3–5, the Levenberg-Marquardt algorithm [31] performs best and has the lowest mean squared error. Therefore, the Levenberg-Marquardt algorithm is the optimal choice as a training function. The results show that BP model can meet the requirements of high error accuracy, high training speed and good generalization performance and meet the needs of comprehensive scientific evaluation of college students' entrepreneurship. From the evaluation results, you can see in Figure 6 that the conversion rate of most college students is not high, the evaluation results for general or entrepreneurial projects account for most of the poor and the conversion rate is over 3%. The unit is not very much, even some entities with an asset conversion rate of less than 3% are in a state of perseverance.

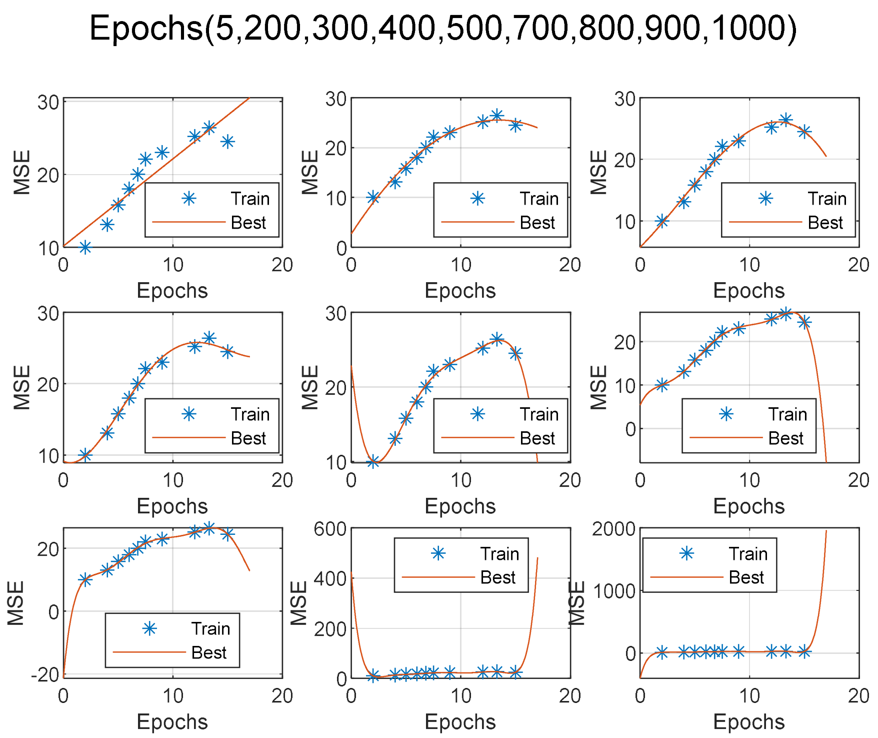


Figure 4. Network training diagram using TrainOSS function and TrainSCG function.

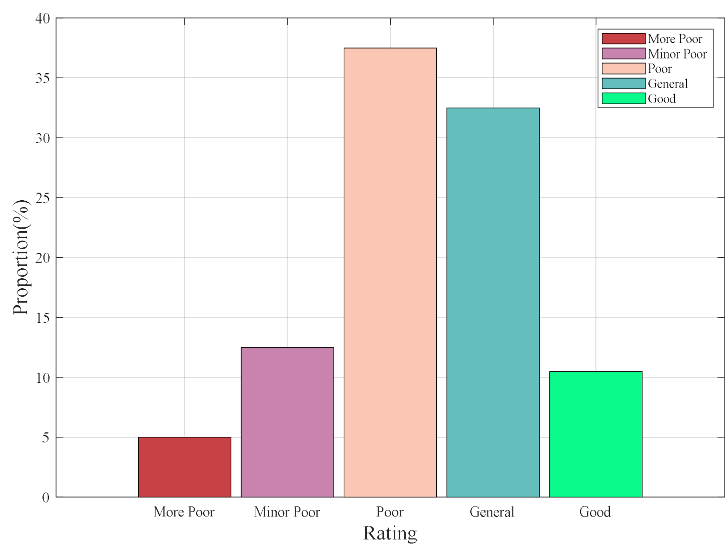
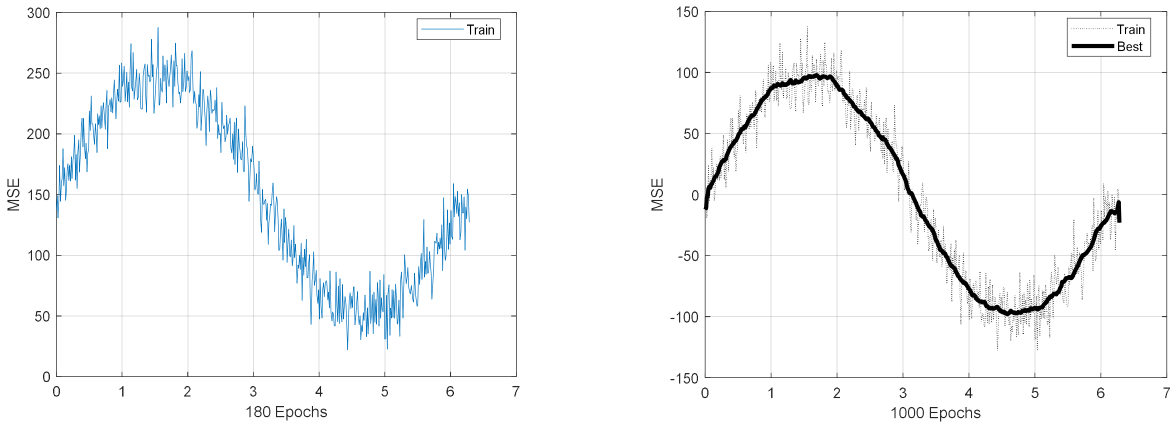


Figure 5. Proportion of evaluation grades.



(a) Urban construction subsystem (b) Ecological construction subsystem

Figure 6. Weight comparison for different dimensions inside each subsystem.

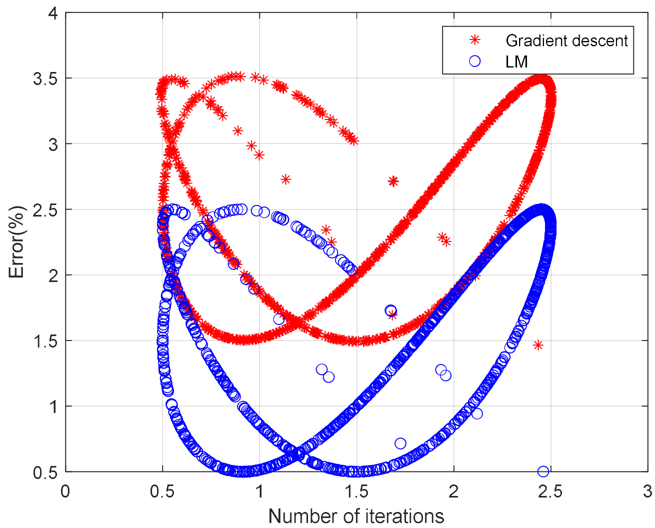


Figure 7. Error comparison of different parameter optimization algorithms.

Based on the experimental results of the double-hidden-layer BP neural network, the error comparison of different parameter optimization algorithms can be obtained as shown in Figure 7.

According to the experimental results of the double-layer BP neural network, the error comparison of different parameter optimization algorithms can be obtained, as shown in Figure 7. From the evaluation results, you can see in Figure 6, most college students' business units in asset conversion rate is not high, the evaluation results for the general or entrepreneurial projects accounted for most of the poor and the conversion rate is above 3% of the unit is not very much, even some units in asset conversion rate lower than 3%, is in a state. As can be seen from Figure 7, the number of nodes in the hidden layer 1 to 20, under the same initial parameter conditions and the number of nodes in the hidden layer 2 to 10 with increasing the number of iterations based on the LM Algorithm [32] training error which is well below the gradient descent method training and through the contrast which is based on the LM algorithm faster convergence speed, can also be found based on the LM algorithm convergence speed which is faster. A comparison of model prediction results is shown in Figure 8.

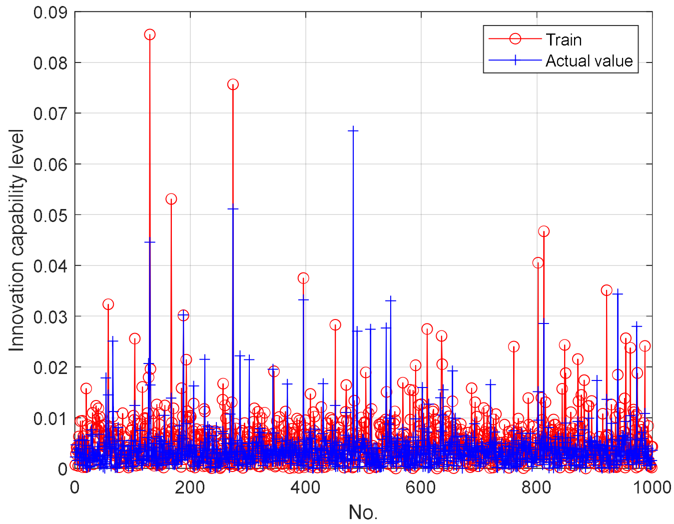


Figure 8. Comparison of model prediction results.

It can be seen from Figure 8 that the prediction value of college students' ability innovation ability model is close to the actual value and the trend of prediction proves that the model has good generalization ability and high prediction accuracy. First, the information gain of each feature attribute was calculated. Then, the optimal sequence combination of features was selected to reduce the influence of noise data on the neural network model. Next, the number of hidden layer nodes is determined by using the non-leaf nodes of the longest regular chain of decision trees, to optimize the structure of the neural network, accelerate convergence speed and reduce errors. Finally, the initial weight of the neural network was optimized by using an improved genetic algorithm and the diversity and convergence of the population are ensured by selecting operators and nonlinear the nonlinear cross-mutation probability value with optimal and worst preservation strategy strategies.

5. Conclusions

Empirical results show that professional knowledge and skills as well as participation in vocational training camps, play an important role in students' innovative entrepreneurship. The higher the score, the stronger the student's innovation base. Some of the students who did well in the evaluation took part in the intensive entrepreneurship training camps. Most of the students who scored high on the assessment took part in social practice. BP can effectively assess students' ability to innovate and start a business. First, the structural design is carried out. then the establishment, training and testing of BP are completed. The evaluation results were determined as models. On this basis, the analysis of professional knowledge and skills, participation in a centralized entrepreneurship training camp and the impact on students' ability to innovate entrepreneurship. There is still room for further improvement in the evaluation model of innovative entrepreneurship education assessment and the relevant data analysis should be improved to the theoretical level. The second is to carry out a comprehensive combing and lay the foundation for comprehensive research on the subject. Finally, comprehensive research data can be used for educational evaluation studies.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

Conflict of interest

The authors declare there is no conflict of interest.

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