

# Evaluation of the education quality of innovation and entrepreneurship in applied colleges and universities based on AHP and BP neural network

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**Abstract:** In order to make a scientific and effective evaluation of innovational and entrepreneurial education in colleges and universities, combining the expert advice, this article takes the applied universities as the research object, which is a new type university, and constructs education quality evaluation index system of innovative universities and colleges from the three dimensions of school, government, society and students. AHP method was used to determine the weight of each index, and sample data was collected through student questionnaires. Then a comprehensive score was calculated. On this basis, an AHP-BP neural network evaluation model was designed, and network training and testing were conducted to evaluate results by AHP method. The results show that the algorithm for the evaluation of the education quality of innovation and entrepreneurship in applied colleges and universities is feasible, highly precise, which also has a strong ability to adapt.

## 1. Introduction

At present, whether the country implements innovation-driven development strategy or the needs of “mass entrepreneurship and innovation” under the new normal of economic development, it is urgent for universities to fully develop innovational and entrepreneurial education and continuously improve the quality of personnel training. Therefore, Scientific and effective evaluation of innovational and entrepreneurial education quality in colleges and universities has important practical significance and value [1-2]. This article will study the research results of the quality evaluation of innovational and entrepreneurial education at home and abroad [3-7], combine the advantages of AHP method and BP neural network method, and combine the two methods to establish an AHP-BP neural network evaluation model. Then, we conduct an empirical quantitative analysis of this applied university, which is a new type university, and provides a scientific basis and reference for the construction of an evaluation system for innovative entrepreneurial education in applied universities.

## 2. Construction of evaluation index system

Deepening the reform and practice of innovational and entrepreneurial education, as an important breakthrough in advancing comprehensive reform in applied universities and accelerating the construction of high-level applied universities, must service to all students. The innovational and



entrepreneurial education must be integrated throughout the entire process of personnel training, combined with professionalism and intensified practice to promote students develop in an all-round way, and cultivate a large amount of "mass entrepreneurship and innovation " as the vital force of this era. Based on this guiding ideology, and following the principles of science, openness, practicality, and guidance, according to the relevant existing research results<sup>[8-9]</sup> and experts (including leaders of education authorities, responsible staff of university science park and entrepreneurship park and related persons in the corporate sector) provided advice and the characteristics of the cultivation of applied talents, we build a set of evaluation index system of innovational and entrepreneurial education quality in applied university with 3-criteria level and 12-indicator level from the three dimensions of the university itself, the government, society, and students, which is shown in Table 1.

Table 1 Evaluation index system of innovational and entrepreneurial education quality in applied university

Target Level	Criteria Level	Indicator Level	Index measure meaning
Evaluation index system of innovational and entrepreneurial education quality in applied university A	School Level B1	Educational goals and concept C11	Whether it has the right concept of innovation, entrepreneurial education and campus culture that are consistent with the goals of the school (1-5 points)
		Funding C12	Whether it has the enough funding for school innovational and entrepreneurial education (1-5 points)
		Management system C13	Whether the school has set up a special innovational and entrepreneurial education management institution and corresponding system safeguards (1-5 points)
		Course System or Module C14	Whether it has set up a perfect innovational and entrepreneurial education curriculum system or module, whether implement effect is good (1-5 points)
		Faculty C15	Whether it is equipped with a high-quality innovative and entrepreneurial education faculty, whether its teaching ability is good (1-5 points)
		Practical teaching and platform C16	Whether the school has carried out lots of innovational and entrepreneurial activities, and whether it has established a perfect practice base and incubation base for innovational and entrepreneurial education (1-5 points)
	Government and Society Level B2	Preferential policies and measures C21	Whether the government had promulgated and implemented preferential policies and measures for innovation and entrepreneurship (1-5 points)
		Social impact C22	Whether the innovational and entrepreneurial education quality in applied university have been approved and recognized by the industry companies, whether they can train high-quality innovative entrepreneurial talents for the industry enterprises (1-5 points)

Student Level B3	Social atmosphere C23	Whether there is a good innovational and entrepreneurial atmosphere and environment in industrial enterprises and whether they can provide necessary posts and practice bases for applied universities (1-5 points)
	Creative knowledge and practice C31	Student's professional skills and the ratio of participating in various types of innovation and entrepreneurship practice activities and projects, which can be selected for in 1 year (1-5 minutes)
	Innovation capability and results C32	The ratio of students' participation in various types of innovation and entrepreneurship practice activities and project winning percentages and rankings, which can be selected for in 1 year (1-5 points)
	Quality of entrepreneurship and entrepreneurial rate C33	The ratio of student's entrepreneurial awareness and thinking and the proportion of entrepreneurial students, which can be selected for one year (1-5 minutes)

### 3. Apply AHP method to determine weights and evaluate

#### 3.1 Apply AHP method to determine weights

Analytic hierarchy process (abbreviated as AHP method) is a method proposed by the famous American economic researcher T.L.Saaty in the mid-1970s to solve multi-criteria and multi-objective complex decision problems. It uses systematic analysis mode combined with qualitative and quantitative analysis. The general idea is to decompose the tedious decision-making problems into an orderly and interrelated hierarchical structure model firstly; in the second step, compare each pair of indicators in each level of the hierarchy model to get their relative importance, and then the relative importance constructs the judgment matrix; the third step calculates the weight of each level index according to each judgment matrix, and conducts the consistency check; finally, according to the index weight of each level, it calculates the combined weight of the whole model, and then combines the weights are multiplied by the survey results of the innovative colleges and universities in applied universities to obtain evaluation results.

In accordance with the above principles, the judgment matrix of the criterion level and the indicator level were construct respectively by consulting the relevant experts and scholars in the form of questionnaires and interviews. The criterion level judgment matrix is shown in Table 2, and then the maximum eigenvalues  $\lambda_{max}$  and the corresponding feature vector were calculated using Matlab. Then it was normalized to obtain its weights  $W_{A-B} = (0.5485, 0.2106, 0.2409)$ , and its  $CR < 0.10$  passes the consistency check.

Table 2 The criterion level Judgment Matrix

A	B1	B2	B3	Weights
B1	1	3	2	0.5485
B2	1/3	1	1	0.2106
B3	1/2	1	1	0.2409

where  $\lambda_{max} = 3.0183$ ,  $CI = 0.0092$ ,  $CR = 0.0158 < 0.10$

Similarly, the weight of each indicator layer can be calculated.

$$W_{B1-C} = (0.1073, 0.1632, 0.0744, 0.1516, 0.2569, 0.2466)$$

$$W_{B2-C} = (0.3694, 0.4065, 0.2241)$$

$$W_{B3-C} = (0.4634, 0.2811, 0.2555)$$

All of above also have passed the consistency test, so that the combinational weights total table of the index for the evaluation of the quality of innovational and entrepreneurial education in applied universities are shown in Table 3.

Table 3 The combinational weights of each index in the evaluation of the quality of innovational and entrepreneurial education in applied universities

Index	Weights	Index	Combination weight	Index	Combination weight	Index	Combinational weight
B1	0.5485	C11	0.0589	C21	0.0778	C31	0.1116
B2	0.2106	C12	0.0895	C22	0.0856	C32	0.0677
B3	0.2409	C13	0.0408	C23	0.0472	C33	0.0616
/	/	C14	0.0832	/	/	/	/
/	/	C15	0.1409	/	/	/	/
/	/	C16	0.1352	/	/	/	/

### 3.2 Comprehensive evaluation using AHP method

In order to provide reference for better carrying out the education of innovation and entrepreneurship in applied colleges and universities, this article starts from the object of education, the student's perspective as the research subjects to conducted evaluations. This survey was conducted in the form of a questionnaire, with students of Hefei University and students graduating in recent years as the survey objects. A total of 300 questionnaires were distributed and 300 were recovered, with an effective rate of 100%, including 142 female students and 158 male students. There are 236 students and 64 graduates, which has certain pertinence and representation. At the school, the government, and the society level, the scores were rated as very unsatisfied, unsatisfied, average, satisfied, and very satisfied. The student level was rated as low, low, average, high, and very high. The scores were 1-5. The Cronbach's Alpha coefficient was used to test the reliability of the questionnaire. The value of Cronbach's Alpha was 0.952, indicating good sample reliability. Table 4 below shows the scores and overall evaluation of the last 10 respondents.

Table 4 Overall Scores and Scores of Indicators for Quality Evaluation of Innovational and entrepreneurial education

	C11	C12	C13	C14	C15	C16	C21	C22	C23	C31	C32	C33	Total score
291	3	4	3	3	4	3	3	3	3	3	3	3	3.2304
292	2	1	3	2	1	3	2	1	2	1	2	2	1.7484
293	5	4	5	5	4	5	5	4	5	5	4	5	4.6163
294	2	3	2	3	3	4	4	5	4	3	4	3	3.3994
295	3	4	3	3	3	3	3	3	3	4	3	3	3.2011

296	2	3	1	4	5	3	3	4	5	1	2	3	3.1136
297	3	4	4	3	2	4	5	3	2	4	4	3	3.4123
298	3	2	3	2	2	3	3	3	2	3	4	2	2.6453
299	4	3	4	4	3	4	3	4	4	3	2	3	3.3832
300	5	3	4	4	3	3	3	4	3	4	3	4	3.5006

#### 4. Comprehensive evaluation based on BP neural network model

##### 4.1 The basic principle of BP neural network

The BP neural network was proposed by scientists led by Rumelhart and McClelland in 1986. It is a multi-layer feed-forward neural network trained according to the error reversal propagation algorithm and is currently the most widely used neural network [10-12]. BP neural network has the ability of memory, learning and self-adaptation because it simulates the working principle of human brain. Its characteristic is that the signal propagates forward and the error propagates backward. Using this method to evaluate the innovational and entrepreneurial education in applied colleges and universities, it is not necessary to build a fixed model in advance. Only use the AHP evaluation results as a sample for learning and training, and then accumulate and use the empirical knowledge, and finally obtain a more satisfactory evaluation result. The BP neural network consists of three parts: the input layer, the hidden layer, and the output layer. The specific structure diagram is shown in Figure 1.

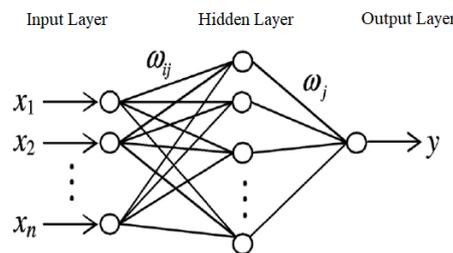


Fig.1 BP neural network structure

The basic idea of the BP neural network is to continuously change the weights and thresholds in the learning and training process so that the error is minimized and the output value is closer to the target value. The specific algorithm is described as follows:

(1) Initialization of weights and thresholds. Randomly give each connection weight  $w_{ij}, w_{jk}$  and corresponding threshold  $\theta_j, \theta_k$ , where  $w_{ij}, \theta_j$  are the weight and threshold from the input layer to the hidden layer, and  $w_{jk}, \theta_k$  are the weight and threshold from the hidden layer to the output layer.

(2) Enter the sample and calculate the output value of each layer. Input sample, the output value of each node can be calculated by the following formula:

$$\begin{cases} z_j = f(\sum_{i=1}^{m_q} w_{ij}x_i - \theta_j), & j = 1, 2, \dots, q \\ y_k = f(\sum_{j=1}^n w_{jk}z_j - \theta_k), & k = 1, 2, \dots, n \end{cases}$$

Where  $f(x)$  is the activate transfer function,  $z_j$  represents the output value of each node in the hidden layer, and  $y_k$  represents the output value of each node in the output layer,  $m, q, n$  are

the amount of points of input layer, hidden layer, and output layer nodes.

(3) Calculate the error based on the target value:

$$\begin{cases} \delta_k = (y'_k - y_k) \cdot y_k \cdot (1 - y_k) \\ \delta_j = \left[ \sum_{k=1}^n \delta_k \cdot w_{jk} \right] z_j (1 - z_j) \end{cases}$$

Where  $\delta_k, \delta_j$  are the output layer, hidden layer error,  $y'_k$  is the sample target value.

(4) Based on the errors, we perform weight and threshold corrections. Output layer errors  $d_k$  and hidden layer outputs  $z_j$  can be used to correct weights value  $w_{jk}$  and thresholds value  $\theta_k$  from the hidden layer to the output layer. Among them,  $0 < \alpha < 1$ .

$$\begin{aligned} w_{jk}(N+1) &= w_{jk}(N) + \alpha \cdot \delta_k \cdot z_j \\ \theta_k(N+1) &= \theta_k(N) + \alpha \cdot \delta_k \end{aligned}$$

Using the hidden layer error  $e_j$  and the input  $x_i$  of layer input, the correction of the weight value  $w_{ij}$  and threshold value  $\theta_j$  from the input layer to the hidden layer can be performed. Among them,  $0 < \beta < 1$ .

$$\begin{aligned} w_{ij}(N+1) &= w_{ij}(N) + \beta \cdot \delta_j \cdot x_i \\ \theta_j(N+1) &= \theta_j(N) + \beta \cdot \delta_j \end{aligned}$$

(5) In the learning process, if the error is acceptable, the learning is completed; otherwise, it returns to step (2) to adjust the step length and the threshold value for further learning until the specified error, accuracy, or training times are satisfied.

#### 4.2 Design of BP neural network structure

(1) The number of network layers. Studies have shown that without restricting the number of hidden layer nodes, the BP neural network structure of three layers (containing only one hidden layer) can achieve arbitrary nonlinear mapping. Therefore, this paper selects a typical three-layer BP neural network model.

(2) The number of input layer nodes. According to the previous analysis of this paper, there are 12 indicators for evaluating the quality of innovational and entrepreneurial education in applied colleges and universities, so the number of input layer nodes corresponds to this, namely 12.

(3) The number of output layer nodes. The evaluation result of the quality of innovational and entrepreneurial education in applied universities is the number of output layer nodes, and therefore the number of nodes is 1.

(4) The number of hidden layer nodes. There is no definite solution for how to determine the number of nodes in the hidden layer. Generally, it is determined based on previous design experience and its own experiment. This article refers to the following empirical formula:

$$q = \sqrt{m + n} + a$$

Where  $m, q, n$  represents the number of input layer, hidden layer, and output layer nodes, and  $a$  takes any constant between 1-10. According to the experience, the final selection of hidden layer node number is 10.

(5) The transfer function. The hidden layer transfer function uses the tangent S function tansig, i.e.  $f(s) = \frac{1 - e^{-s}}{1 + e^{-s}}$ , and the output layer transfer function uses the simple linear function purelinn.

#### 4.3 Training and testing of BP neural network

The grading data of the evaluation index of innovational and entrepreneurial education in applied universities

was used as the BP neural network input, and the AHP evaluation result was used as the target value for network training. Before data input, the normalization process was performed at first, then 250 samples were randomly selected as training samples for network training, and the remaining 50 samples were used as test samples for network testing. Before training, first set the training parameters, in which the initial learning rate is 0.01, the maximum number of learning iterations is 500, the training end error is 0, the training results shown in Figure 2, indicating that the network error after iteration 500 close to meet the provisions Error accuracy requirements. The comparison of the actual output value of the trained BP neural network with the predicted value is shown in Fig. 3. From Fig. 3, it can be seen that the actual output of the training sample is highly fitting with the expected output, with an accuracy of 99.9992%.

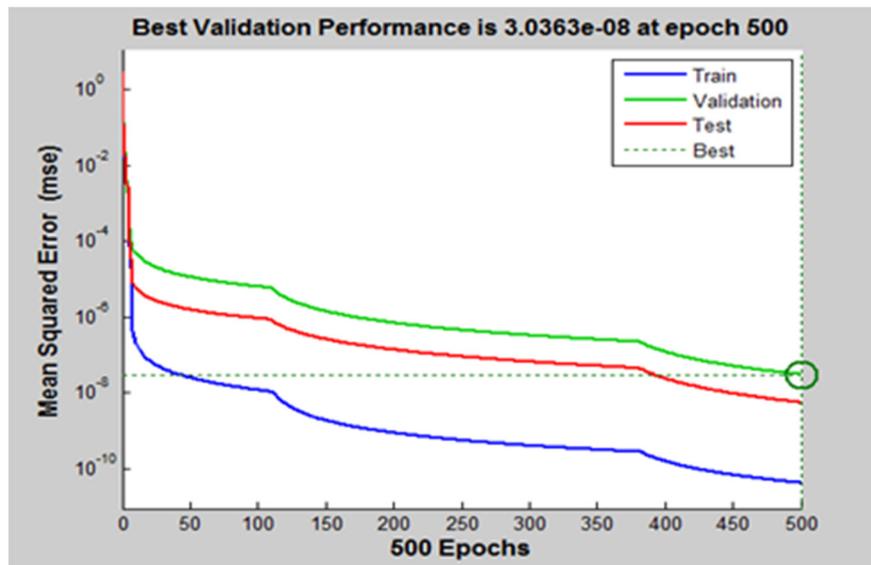


Fig. 2 BP neural network training results

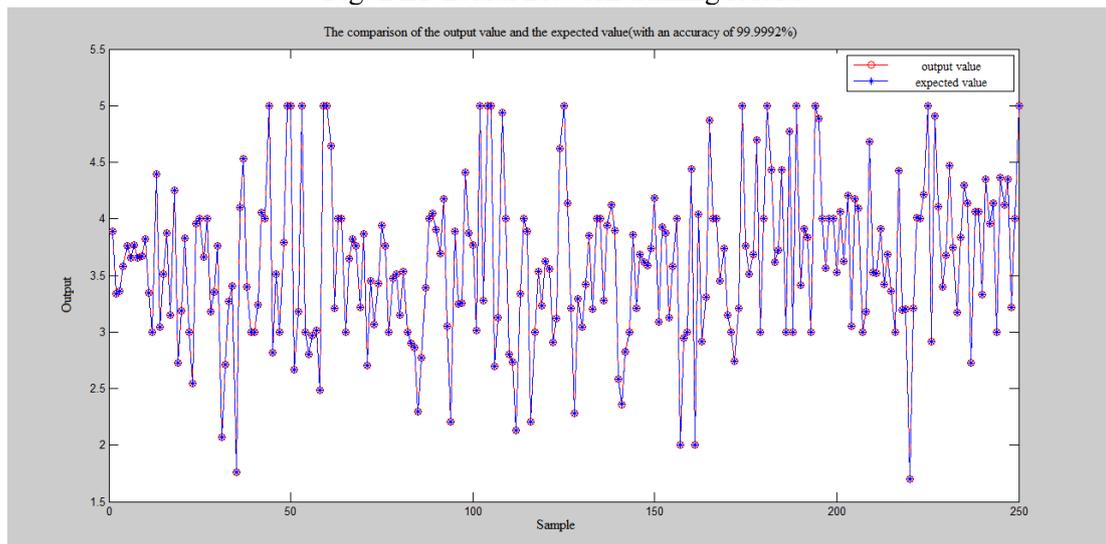


Fig. 3 Comparison between output and expected value of trained BP neural network

Using the trained BP neural network model to test the test of the last 50 samples, the comparison of the output value and the expected value is shown in Fig. 4. It can be seen from Fig. 4 that the BP neural network model constructed in this paper has a good simulation effect. The actual output of the sample is highly consistent with the expected output, with an accuracy of 99.9916%. The specific test results and errors of the last 10 respondents are shown in Table 5. The error rate is very small and

almost negligible, indicating that the model has very good generalization ability and predictive evaluation level have good application and popularization value for the evaluation of the quality of innovational and entrepreneurial education in applied universities.

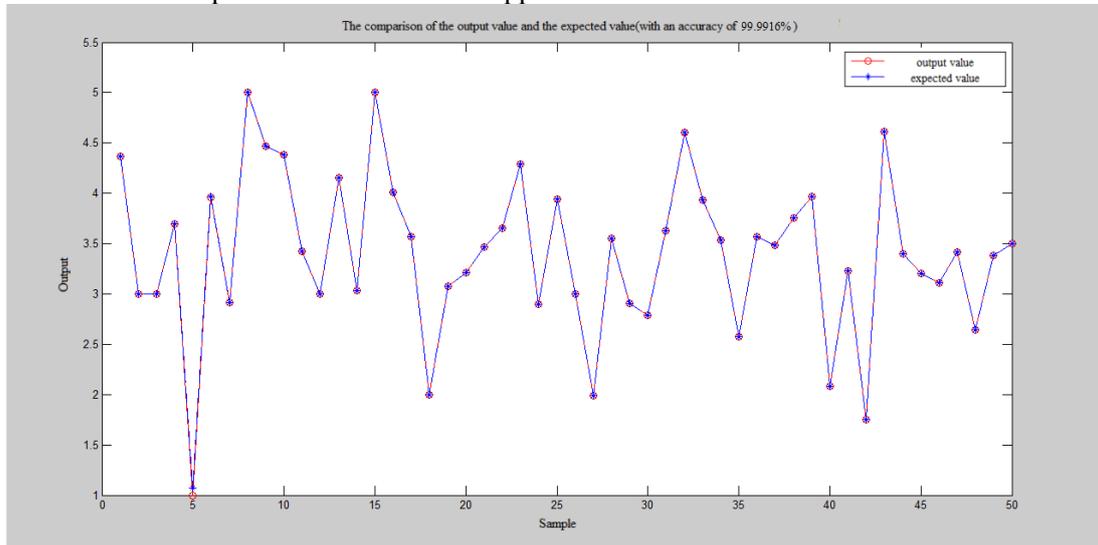


Fig.4 Comparison between output and expected value of BP neural network of test sample

Table 5 Test Results and Errors

No.	Actual output	Expected output	Error rate (%)
291	3.2305	3.2304	-0.0031
292	1.7521	1.7484	-0.2116
293	4.6164	4.6163	-0.0022
294	3.3996	3.3994	-0.0059
295	3.2013	3.2011	-0.0062
296	3.1133	3.1136	0.0096
297	3.4124	3.4123	-0.0029
298	2.6451	2.6453	0.0076
299	3.3833	3.3832	-0.0030
300	3.5005	3.5006	0.0029

#### 4.4 BP Neural Network Evaluation Results and Analysis

A comprehensive evaluation of 300 samples was conducted using a trained BP neural network model. The primary indicators and the final evaluation results are shown in Table 6. From Table 6, it can be seen that both the overall evaluation and the partial evaluation, the scores are not high and they are moderate level, which is in line with reality. It shows that there is still much room for development and improvement.

Table 6 First-level indicators and final evaluation results

Indicator	School Level	Government and Society Level	Student Level	Overall Evaluation
Result	3.5881	3.5947	3.5084	3.5697

## 5. Conclusion

On the basis of previous research, this article first draws on the theory of stakeholders, takes the new type of applied university as the research object, and combines expert advice to construct an evaluation index system of innovational and entrepreneurial education in applied universities from three dimensions. Weights of AHP method were obtained through Experts and scholars scored; then combined the AHP method with BP neural network method to construct an AHP-BP neural network evaluation model, and through the distribution of student questionnaires, taking the AHP evaluation results as the goal, from the perspective of students on the BP neural network training, testing, and simulation are performed to reduce the influence of subjective human factors evaluation by experts and scholars, while giving full play to the important role of students in education evaluation, making evaluation more realistic, accurate, reliable, and practical.

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