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Evaluation of Teachers' Innovation and Entrepreneurship Ability in Universities Based on Artificial Neural Networks

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ABSTRACT

Based on iceberg theory and the questionnaire of competency's elements, hierarchical index system of evaluation of teachers' innovation and entrepreneurship competency in universities is established. Through researches, the authors think that analytic hierarchy process (AHP) is a more scientific and reasonable evaluation method whose rationality is checked by satisfactory consistency while the evaluation model of artificial neutral network doesn't consider weighting. If the samples are more than 30, the evaluation of neural network model of teachers' innovation and entrepreneurship competency can achieve the accurate results and satisfactory requirements. Since the method of artificial neutral network has advantages of strong operability, simple rules, and minor errors, it can greatly reduce the workload because it not only eliminates human subjectivity of evaluation and greatly simplifies the process of evaluation, but also improves working efficiency and provides a new way of thinking for evaluation of the teachers' innovation and entrepreneurship competency in universities.

KEYWORDS

AHP, Artificial Neural Network, Competency Evaluation, Innovation and Entrepreneurship Competency

1. INTRODUCTION

As China's economy has ushered in a new normal and the economic growth is innovation-driven other than previously investment- and factor-driven, innovation and entrepreneurship research has become a focused area in higher vocational colleges. As the direct performers of talent training, teachers need to strengthen their innovation and entrepreneurship competency so as to improve the overall level of these competencies in higher vocational colleges. However, in the academic circle, there is a research gap in the evaluation and promotion strategies of college teachers' innovation and entrepreneurship competency. How to evaluate the innovation and entrepreneurship competency of teachers in the higher vocational colleges to help improve such competencies has become one of the core issues in the reform and development of higher vocational education(Lee et al.,2011; White,1959).

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Iceberg model theory was put forward by famous American psychologist McClelland in 1973(McClelland, 1973). According to the different manifestation of individual qualities, professor McClelland classified iceberg into two parts, one is superficial "part of the iceberg above the surface," and the other is deep "part of the iceberg below the surface" The "part of the iceberg above the surface" that includes knowledge and skills are the external manifestations which can easily be understood and measured. Thus they are relatively easy to change through training and development. The "part of the iceberg below the surface" that includes social roles, self-image, features, and motivation are the internal manifestation and difficult to be measured. Although this part is less likely to be influenced and changed by the surroundings, it plays a crucial role in people's behavior and performance. McClelland thinks that traditional intelligence and aptitude tests cannot predict people's professional success and other important achievements (McClelland,1998). He advocates the exploration of individual conditions and real behavioral characteristics, which is called the competency that affects job performance. Many researchers believe that the competency model is becoming an important part of human resource management, so modern enterprise management should use competency evaluation to predict job performance (Shipmann et al.,2000; Sandberg,2002; Yamazaki,2014; Parry,2009; Smolensky,1986).

Western studies of competency evaluation of teachers in universities started earlier. Representative methodologies are as follows: balanced scorecard, statistical analysis, Markov chain method, Analytic Hierarchy Process (AHP), comprehensive evaluation method, management by objectives, key performance indicators(Spencer and Spencer,1993; Boyatzis,1982; Glockshuber,2007; Stewart,2010; Erlich and Shaughnessy,2014) and so on. Chinese scholars have been continually improving and complementing models, methods, and techniques of teachers' competency evaluation on the foundation of the experiences and results of western studies(Zhong,2011). Scholars such as Wang (2005), Qin(2007), and Zhang(2009) have used the method of 360-degree feedback on the evaluation of teachers' performance, putting forward relevant evaluation criteria, procedures, and implementing strategies. Guo (2006), Xu (2007), and Cao (2012) have studied programs, models, and management of the performance evaluation of the teachers based on the balanced scorecard in universities. Xu (2007) has used AHP and fuzzy mathematics to establish an evaluation model. Zhu(2007) has analyzed the cases in universities by means of rough set theory and distinguished matrix to explore the rules of evaluation and obtain objective weighting of evaluating factor. Chen (2012) has made empirical analysis on the evaluation of teachers, suggesting the index of evaluation should be designed from developing strategies in the university. Su(2007) has applied AHP to the evaluation of teachers to determine the weight and build the right index of the evaluation system. Huang et al.(2020) have analyzed the influence of university students' learning beliefs on their intentions to use mobile technologies in learning. Owusu(2020) has analyzed the determinants of Cloud Business Intelligence Adoption Among Ghanaian SMEs. Amo et al.(2020) has designed and implemented a solution based on a student's data pseudonymization through aliases to enable adequate levels in confidentiality issues.

In summary, there are some achievements in the research methods of the current evaluation of teachers in universities at home and abroad. However, researches on the evaluation performance of the teachers' innovation and entrepreneurship competency by means of neural network in universities are rarely few. Many universities in PETOE haven't established a scientific system of evaluation in accordance with the characteristics and job requirements of teachers' innovation and entrepreneurship competency in universities. Evaluation of teachers' innovation and entrepreneurship competency has become an important breakthrough in human resources management in universities.

As for the neural network, it is a very important area for people to explore mimicking the human brain system to process information (Poggio and Girosi,1990; Saavedra-Rivano,2020). From the M-P neuron model established by psychologist Mcculloch and Pitts in 1943 up to now, the neural network model, learning algorithms, implementation, and application of neural computer have made encouraging fruitful results. The most important difference of the neural network evaluation method is in the form of intelligent computing that can avoid subjectivity. As a branch of artificial intelligence, the neural network is similar to the basic structure of computer program of human brain learning (Stinchcombe and White,1989). Compared with other methods, another important advantage of the neural network is more powerful in data processing, which contributes to its special structure. There are a limited number of the neutral hidden layer which can estimate any continuous function and ultimately achieve the desired accuracy (Narendra and Parthasarathy,1990). A neuron represents the receiving, processing, transmitting data model to the next level of processing unit time.

Under ideal conditions, in the face of a particular task, the neural network must be optimized in the composition of the entire parameter space of learning rate, momentum rate, implied layer, the number of nods, the combination of input variables, triggering functions, and so on. To achieve optimization, the computational burden may be relatively large. In this regard, neural network design is considered an art rather than a science(Kawakami and Hirasawa,1992). Anyway, the main goal of the design of a neural network is to minimize error. In other words, it can also be considered to optimize the network topology (Widrow and Lehr,1990). With the further improvement and development of the neural network, it will play a greater crucial role in science and technology.

In view of the fact that the artificial neural network can fully approximate any complex nonlinear relationship and has strong robustness and fault tolerance, it can learn and adapt to unknown or uncertain systems and can process quantitative and qualitative knowledge at the same time, and this paper attempts to apply neural network into the evaluation of teachers' innovation and entrepreneurship competency with the theory of iceberg model and the foundation and comparison of AHP method to achievement a relatively more accurate and intelligent way to evaluate teachers' innovation and entrepreneurship competency in universities.

2. CASE OF EVALUATION OF AHP OF TEACHERS' INNOVATION AND ENTREPRENEURSHIP COMPETENCY IN W UNIVERSITY

2.1 Establishment of Evaluation System of Teachers' Innovation and Entrepreneurship Competency

At present, there are a number of factors of the evaluation of teachers' innovation and entrepreneurship competency in universities, and the structure is complicated. According to the characteristics of the work of teachers' innovation and entrepreneurship competency in universities and the competency model of iceberg theory proposed by Spencer, this paper establishes hierarchical structure(see Table 1) from four aspects of Feature Competency, Technology Competency, Practice Competency, and Society Competency as well. The uppermost layer is called the target layer, which is a predetermined objective to analyze the problem. The intermediate layer is called the criterion layer or index layer, and the lowermost layer is called the scheme layer or object layer. The structure of evaluation of teachers' innovation and entrepreneurship competency is as follows: The structure of feature competency refers to teachers' quality in innovation, which is for teachers to complete innovation and entrepreneurship education work. The structure of technology competency reflects teachers' relevant skills in innovation. Practice competency reflects college teachers' entrepreneurial practice-related competency, and society competency reflects college teachers' ability to adapt to society. Among the four dimensions of competency, feature competency and society competency can be regarded as invisible competencies, while technology competency and practice competency are visible competencies.

This paper uses SPSS19.0 for the sample questionnaires, and we find two coefficients are both more than 90%, so there are high internal consistency and strong reliability for the questionnaires, which can be analyzed in depth(see table 2).

Reliability analysis of the questionnaire of the importance of elements of teachers' innovation and entrepreneurship competency in universities is shown in Table 1.

Table 1. Reliability analysis

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.936	.964	24

2.2 Establishment of Judgment Matrix

The judgment matrix is fundamental to calculate importance. We assume that the target layer of "U" has the dominant relationship to the object layer U_1, U_2, U_3, U_4. For the target layer U, the importance of U_i and U_j need to be compared and determined, and the "importances" need to be given certain values. For the 4 index elements of the indicators, pairwise comparison judgment matrix(U_{ij})4×4 can be obtained. Uij represents how important the indicators of U_i and U_j for targets.

Index System of Innovation and Entrepreneurship Competency Evaluation is shown in Table 2.

Obviously, matrix(U_{ij})4×4 is featured as follows:

1)U_{ij}>0
2)U_{ij} =1/ U_{ji}(i¹j)
3)U_{ii} =1/(i,j=1,2,3,4)

For matrix(U_{ij})4×4, if for any i, j, k, there is U_{ij} • U_{jk} = Uik, the matrix(U_{ij})4×4 is the consistent matrix.

To determine the specific values of the judgment matrix, T.L.Saaty proposed the scale of 1-9, and the meaning is shown in table 3:

In this paper, the layer U of performance objective of teachers' innovation and entrepreneurship competency in universities for the next layer index layer U1, U2, U3, U4 and the judgment of the matrix of the index layer and the object layer are formed by seven experts who fill in the inquiry forms (see tables from 4 to 8).

Judgment matrix of U— index layer U_i of indicator system of innovation and entrepreneurship competency is shown in table 4.

Judgment matrix of U_1— object layer of indicator system of innovation and entrepreneurship competency is shown in Table 5.

Judgment matrix of U2— object layer of indicator system of innovation and entrepreneurship competency is shown in Table 6.

Judgment matrix of U.3— object layer of indicator system of innovation and entrepreneurship competency is shown in Table 7.

Judgment matrix of U4— object layer of indicator system of innovation and entrepreneurship competency is shown in Table 8.

2.3 Consistency Check

Only when the matrix is exactly consistent, there is λ1=λmax=n, and other latent roots are zero; when judgment matrix is not exactly consistent, λmax=n, other latent roots have the following relationship (see equation 1):

$$\sum_{i=2}^{n} \lambda_i = n - \lambda_{\max} \tag{1}$$

Table 2. Index System

Target Tier	Criterion Tier	Level 1 Indicator	Code	Level 2 Indicator	Code
Innovation and Entrepreneurship Competency Evaluation of Teachers in Industry-Oriented Higher Vocational Colleges	Innovation Competency	Feature Competency	U1	Innovation Willpower	U11
				Innovation Thinking	U12
				Achievement Motivation	U13
				Risk-taking Propensity	U14
				Emotional Stability	U15
				Decisive Power for Action	U16
				Independent Work Competency	U17
		Technical Competency	U2	Technical Learning Competency	U21
				Technology Development Competency	U22
				Knowledge Transformation Competency	U23
	Entrepreneurship Competency	Practice Competency	U3	Opportunity Recognition Competency	U31
				Enterprise Management Competency	U32
				Risk Prevention Competency	U33
				Financial Management Competency	U34
				Market Development Competency	U35
				Marketing Competency	U36
				Human Resources Management Competency	U37
		Society Competency	U4	Leadership	U41
				Communication Competency	U42
				Self-control Competency	U43
				Environmental Resilience Competency	U44
				Teamwork Competency	U45
				Resource Integration Competency	U46
				Problem Solving Competency	U47

Table 3. Scale of judgment matrix and its meaning

No.	Element importance level(i to j)	Uij valuation
1	i is equally important with j	1
2	i is a little bit important than j	3
3	i is obviously important than j	5
4	i is strongly important than j	7
5	i is extremely important than j	9
6	i is a little bit less important than j	1/3
7	i is obviously less important than j	1/5
8	i is strongly less important than j	1/7
9	i is extremely less important than j	1/9

NOTE: U_{ij}={2,4,6,8,1/2,1/4,1/6,1/8} indicates their levels of importance between U_{ij}={1,3,5,7,9,1/3,1/5,1/7,1/9}.

Table 4. Judgment matrix of U_i

U	U_1	U_2	U_3	U_4
U_1	1	1/2	2	3
U_2	2	1	3	4
U_3	1/2	1/3	1	2
U_4	1/3	1/2	1/4	1

Table 5. Judgment matrix of U_{1i}

U_1	U_{11}	U_{12}	U_{13}	U_{14}	U_{15}	U_{16}	U_{17}
U_{11}	1	1	1/3	1/2	1	1	1/4
U_{12}	1	1	1/3	1/2	1	1	1/5
U_{13}	3	3	1	2	3	3	1/2
U_{14}	2	2	1/2	1	2	2	1/3
U_{15}	1	1	1/3	1/2	1	1	1/5
U_{16}	1	1	1/3	1/2	1	1	1/6
U_{17}	4	5	2	3	5	6	1

Table 6. Judgment matrix of U_{2i}

U_2	U_{21}	U_{22}	U_{23}
U_{21}	1	1/2	3
U_{22}	2	1	5
U_{23}	1/5	1/3	1

Table 7. Judgment matrix of U_{3i}

U_3	U_{31}	U_{32}	U_{33}	U_{34}	U_{35}	U_{36}	U_{37}
U_{31}	1	1/4	1/3	1	1/3	1/3	1/6
U_{32}	4	1	2	4	2	3	1/2
U_{33}	3	1/2	1	3	1	2	1/4
U_{34}	1	1/4	1/2	1	2	1/2	1/7
U_{35}	3	1/2	1	1/2	1	2	1/3
U_{36}	3	1/3	1/2	2	1/2	1	1/5
U_{37}	6	2	4	7	3	5	1

Table 8. Judgment matrix of U_{4i}

U_4	U_{41}	U_{42}	U_{43}	U_{44}	U_{45}	U_{46}	U_{47}
U_{41}	1	2	2	1	3	3	2
U_{42}	1/2	1	1	1/2	2	2	1
U_{43}	1/2	1	1	1/2	2	2	1
U_{44}	1	2	2	1	3	3	2
U_{45}	1/3	1/2	1/2	1/3	1	1	1/2
U_{46}	1/3	1/2	1/3	1/3	1	1	1/2
U_{47}	1/2	1	1/3	1/2	2	2	1

Therefore, the difference $\lambda_{max}=n$ can be used to test the degree of coherence. At present, CI (Consistency Index) is used as the consistency index (see equation 6). The smaller the CI is, the greater the consistency is.

$$CI = \frac{\lambda_{\max} - n}{n - 1} \quad (2)$$

Obviously, for the mutual consistent positive and negative matrix, there is CI=0,λ1=λmax=n judgment matrix is completely consistent. But, it is not enough to rely on value CI to judge whether there is a consistency check for matrix A, Sometimes the average random consistency index RI needs to be introduced. Value R from band 1 to 9 is shown in table 9.

Index of average consistency is shown in Table 9.

For 1 and 2 order judgment matrix, RI is only formal. When CR=CI/RI£0.1, there is satisfactory consistency for the judgment matrix. After calculation, the judgment matrix has passed the consistency test. Results are shown in Table 10.

Table 9. Index of average consistency

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Table 10. Calculating results of consistent

	CR	λ_{max}	*CI*	*RI*
target-U	0.0115	4.0310	0.0103	0.9
Feature Competency - U_1	0.0031	7.0247	0.0041	1.32
Technology Competency - U_2	0.0032	3.0037	0.0018	0.58
Practice Competency - U_3	0.0559	7.4431	0.0739	1.32
Society Competency - U_4	0.0026	7.0203	0.0034	1.32

2.4 Hierarchical Ordering

Judgment matrix is the calculated basis of AHP, AW=λmaxW is used to solve λmax corresponding feature vector W of λmax, which is normalized, namely the weighting coefficient of the corresponding index of the same level for some indicator of the top level. The root method is used in this paper. Calculating methods are seen in formula (3), formula (4), and (5). The results are in table 11.

Table 11. Total weight of each element

	1st level	**weight**	**2nd level**	**Stratification weight**
			U_{11}	0.0729
			U_{12}	0.0706
			U_{13}	0.2151
	U_1	0.2776	U_{14}	0.1320
			U_{15}	0.0706
			U_{16}	0.0688
			U_{17}	0.3699
			U_{21}	0.3090
	U_2	0.4668	U_{22}	0.5816
			U_{23}	0.1095
			U_{31}	0.0442
			U_{32}	0.2139
			U_{33}	0.1251
	U_3	0.1603	U_{34}	0.0592
			U_{35}	0.1009
			U_{36}	0.0802
			U_{37}	0.3766
	U_4	0.0953	U_{41}	0.2371
			U_{42}	0.1287
U			U_{43}	0.1287
			U_{44}	0.2371
			U_{45}	0.0699
			U_{46}	0.0699
			U_{47}	0.1287

1)To calculate the product M_i

$$M_i = \prod_{j=1}^{n} a_{ij} \quad (i = 1,2,\cdots,n) \tag{3}$$

To calculate n-th root $_I$ o$_{f\ i}$

$$\overline{W_i} = \sqrt[n]{M_i} \tag{4}$$

To normalize the vector $=1,2,\ldots,_n{}^T$

$$W_i = \overline{W_i} \Big/ \sum_{j=1}^{n} \overline{W_j} \tag{5}$$

Therefore, $W=W_1,W_2,\ldots,W_n{}^T$ is the feature vector of seeking weight.

Therefore weight vector of a set of elements for some element on a topper layer is obtained, and finally, the sequence weight of the various elements of the level of the lowest program for the target is gained. Thereby, the selection of program is conducted. The calculation of the total weight is composed of the top down in accordance with a single criterion.

In order to facilitate research, only part of the data of the questionnaire of competency evaluation is selected in W University. We select 34 questionnaires of self-evaluation of teachers' innovation and entrepreneurship competency as samples and calculate the results according to the weight determined in table11. Results are shown in Table 12.

3. APPLICATION OF EVALUATION OF ARTIFICIAL NEURAL NETWORKS OF TEACHERS' INNOVATION AND ENTREPRENEURSHIP COMPETENCY IN GRP

The factors of evaluation of teachers' innovation and entrepreneurship competency in universities are Innovation Willpower, Innovation Thinking, Achievement Motivation, Risk-taking Propensity, Emotional Stability, Decisive Power for Action, Independent Work Competency, Technical Learning Competency, Technology Development Competency, Knowledge Transformation Competency, Opportunity Recognition Competency, Enterprise Management Competency, Risk Prevention Competency, Financial Management Competency, Market Development Competency, Marketing Competency, Human Resources Management Competency, Leadership, Communication Competency, Self-control Competency, Environmental Resilience Competency, Teamwork Competency, Resource Integration Competency, and Problem Solving Competency. Results and inclusions of 34 self-assessment are taken for the study samples, using Matlab R2012b to make simulation evaluation.

Using x_{ij} to represent the evaluation score of i-th element of the j-th teacher in the original data, $i = 1,2, ..., 24$, $j = 1,2, ..., 34$. y_j shows evaluation score of the j-th teacher in raw data, $j = 1,2, ..., 34$. 30 teachers from ZP001 to ZP 030 are chosen as the learning sample set, 4 data from teacher ZP 031 to ZP034 as the test sample set. Network is trained by the means of learning sample set and then the trained neural network is used to evaluate teachers from ZP031-034 to obtain evaluating value of the networks, which are compared with the actual value of the test samples.

Table 12. Results of evaluation of AHP of teachers' innovation and entrepreneurship competency in W university

No.	Sex	Age	Title	Score of evaluation
ZP001	M	38	lecturer	8.171236
ZP002	M	53	A.P.	8.057526
ZP003	M	46	A.P.	8.051344
ZP004	M	36	lecturer	8.384824
ZP005	M	39	A.P.	7.957929
ZP006	M	36	lecturer	8.261267
ZP007	M	35	lecturer	8.625388
ZP008	M	36	A.P.	7.031283
ZP009	M	38	A.P.	7.072217
ZP010	M	45	Prof.	8.247954
ZP011	M	32	lecturer	7.214198
ZP012	M	43	Prof.	7.595864
ZP013	M	48	Prof.	8.536483
ZP014	M	44	A.P.	7.567526
ZP015	M	31	lecturer	8.492185
ZP016	M	53	A.P.	8.385913
ZP017	M	55	Prof.	7.743958
ZP018	M	38	A.P.	8.560462
ZP019	M	44	Prof.	7.810079
ZP020	M	48	A.P.	8.185521
ZP021	M	36	lecturer	8.419903
ZP022	F	35	lecturer	8.610484
ZP023	F	48	Prof.	7.95943
ZP024	F	33	assistant	8.210952
ZP025	F	32	lecturer	7.241441
ZP026	F	44	A.P.	8.124543
ZP027	F	36	assistant	8.378991
ZP028	F	32	assistant	8.476565
ZP029	F	58	Prof.	7.827661
ZP030	F	33	lecturer	7.982569
ZP031	F	34	assistant	7.996101
ZP032	F	40	A.P.	8.16841
ZP033	F	37	lecturer	7.610157
ZP034	F	34	assistant	8.007975

3.1 Normalization of Sample Data

In order to eliminate the differential of the raw data, generally the data requires a unified dimension. So here the function premnmx of Matlab is selected to pre-process and post-process the raw data. Normalization algorithm of the function is shown as the formula (6) as follows:

$$pn=2*(p-minp)/(maxp-minp)-1 \tag{6}$$

in which: *pn* is the standardized input matrix of $R\times Q$ dimension; *p* is the input matrix of dimension $R\times Q$; *minp* is the vector of minimum value of each component of p which is included in $R\times 1$dimension; *maxp* is the vector of the maximum value of each component of *p* which is included in $R\times 1$ dimension.

3.2 Determination of the Number of the Nodes in Hidden Layer

BP (Back Propagation) neural network is widely used as about 80% of the neural network models have used BP networks or the variant forms(Szewezyk and Hajela,1994). So BP neural networks are chosen to evaluate teachers' innovation and entrepreneurship competency in W university. However, in practice, estimation of nodes in hidden layer has been a difficult key in network structure. The current researches are numerous, but there are still no definite conclusions. In 1989, Robert Hecht-Nielson demonstrated a BP network with 3-layer, which can be mapped from n-dimension to m-dimension. That is to say, it can approach any continuous function. So there is 1 input layer, 24 nodes; a hidden layer, l node; 1 output layer, 1 node in the BP network designed here. The number of the l of nodes of the hidden layer is generally determined by:

$$l=\sqrt{m+n}+a \tag{7}$$

$$l=\log_2 n \tag{8}$$

$$l=\sqrt{0.43mn+0.12n^2+2.54m+0.77n+0.35}+0.51 \tag{9}$$

In (7) (8) (9), m is the number of the input nodes; n is the number of the output nodes; *a* is the constant between 1 to 10.

According to these empirical formulas, the number of the hidden layer nodes should be between 3 to 15. To confirm the number, 3 kinds of activation functions of tansig, elliotsig and logsig in MATLAB from node 1 to 18 for the simulation results are selected and compared. Results are shown in Table 13, Table 14 and Table 15 below.

From the results of table13, table 14, and table 15, the relative error of logsig function is minimized. In addition, the performance of different training functions will have an impact on the network. four kinds of training functions of the traingda, traingdm, traingdx and trainlm and network training are compared in this paper (see Figure 1 to Figure 4(Neuron number of hidden layer is 6).

Figure 1. Training results of traingdx function

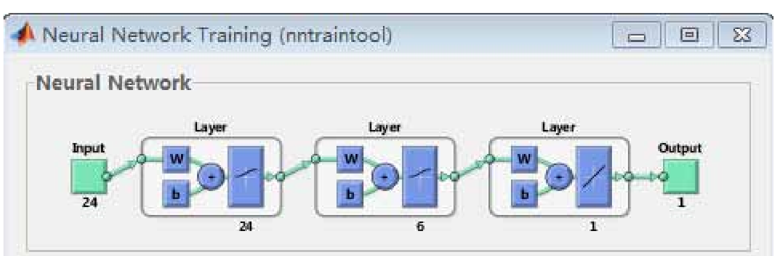


Figure 2. Training results of traingda function

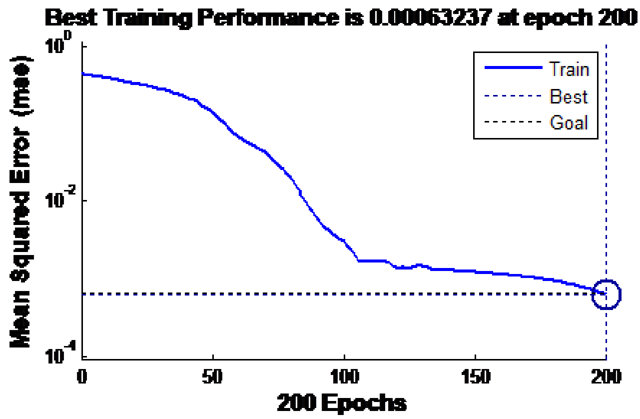


Figure 3. Training results of traingdm function

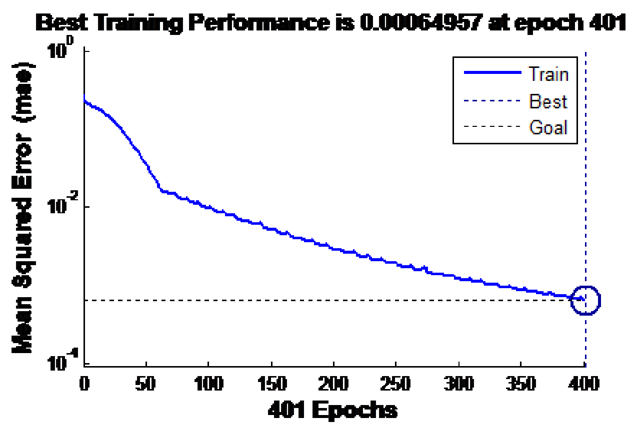


Figure 4. Training results of trainglm function

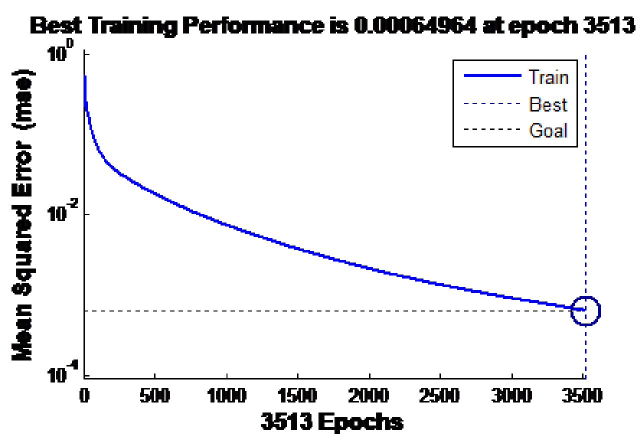
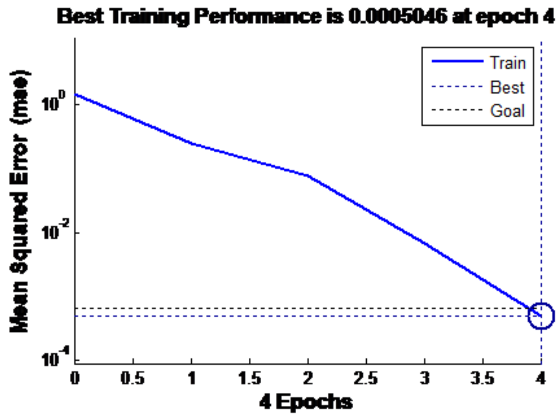


Figure 5. BP neural network model of evaluation of Teachers' innovation and entrepreneurship competency



From figure 4, the requirement for network training error has reached in the case of smaller training steps with trainlm training function. The number of neurons in the hidden layer is chosen to be 6.

Therefore, the model of the BP neural network of evaluation of teachers' innovation and entrepreneurship competency has confirmed an input layer, 24 nodes, logsig function of activation function; a hidden layer, six nodes, logsig function of activation function; an output layer, a node,

Table 13. Relative error of tansig function for each node selected

No. of nodes	Tansig function				Relative error				Mean square error of relative error
					ZP031	ZP032	ZP033	ZP034	
1	7.6326	8.4207	7.6839	8.1435	-4.5460	3.088606	0.969008	1.692375	2.915841
2	8.3256	8.3681	7.3217	7.7047	4.1207	2.444662	-3.79042	-3.78716	3.593981
3	7.6261	8.3396	7.7808	8.2803	-4.6273	2.095757	2.242306	3.400672	3.255623
4	7.9857	8.2296	7.9113	8.0532	-0.1301	0.749105	3.957119	0.56475	2.034442
5	8.1057	8.28	7.7582	8.318	1.3707	1.366117	1.945334	3.871453	2.372628
6	8.0156	7.8639	7.5229	7.7017	0.243856	-3.7279	-1.14659	-3.82462	2.734004
7	7.9333	8.2692	7.9315	7.7864	-0.7854	1.2339	4.222554	-2.76693	2.627985
8	8.109	7.8464	7.6549	7.918	1.411926	-3.94214	0.587938	-1.12357	2.187582
9	8.0347	8.3216	7.7514	8.1237	0.482723	1.875396	1.85598	1.445122	1.523415
10	8.3322	8.3546	7.9027	8.0773	4.203286	2.279391	3.844113	0.8657	3.097978
11	8.1569	8.0733	7.5095	7.7705	2.010968	-1.16436	-1.32267	-2.96548	1.996451
12	7.9487	8.5079	8.1339	7.7683	-0.5928	4.156133	6.882158	-2.99295	4.299614
13	7.9665	7.986	7.8194	8.1451	-0.37019	-2.23312	2.749523	1.712355	1.975847
14	8.6759	8.4127	7.588	7.4754	8.501631	2.990668	-0.29115	-6.65056	5.602154
15	8.4101	8.2575	7.4894	8.7369	5.177511	1.090665	-1.58679	9.102488	5.323752
16	8.4636	7.7097	8.0777	7.892	5.846587	-5.61566	6.143671	-1.44824	5.137127
17	8.2001	8.1615	7.8646	8.0588	2.551231	-0.08459	3.343466	0.63468	2.127059
18	8.103	8.9869	7.9614	7.8806	1.336889	10.02019	4.61545	-1.5906	5.613017
Mean value	8.1125	8.2438	7.7591	7.9908	1.4559	0.9235	1.9567	-0.215	3.2455

purelin function of the activation function (see figure 5). Training function of trainlm is selected, and MATLAB program code is omitted here. Evaluation results are obtained with the use of this network (see table 16). From the above results of the evaluation, the model of BP neural networks for evaluation of teachers' innovation and entrepreneurship competency can achieve the effect of the AHP method (see table 12 and table 16). Compared with the testing results of AHP, the biggest error of the results by means of a neutral network is only 2.38%. Moreover, from the above results, it can be seen that the evaluation of teachers' innovation and entrepreneurship competency based on AHP method has strong subjectivity, complicated operation hierarchies, and other problems. However, the evaluation based on ANN method with sample training, which is more intelligent, objective, and operational, can be directly used for the subsequent evaluation of teachers' innovation and entrepreneurship competency.

4. CONCLUSION

The application of artificial neural networks into the evaluation of teachers' innovation and entrepreneurship competency is an attempt to learn from nature. From the results of the evaluation, teachers can correct understanding of their own position, identify problems and improve themselves.

In practice, evaluation of teachers' innovation and entrepreneurship competency is mainly operated in various colleges and universities, and the use of AHP evaluation will involve different weights, so in general, the results of the evaluation in various universities will be different because of the different emphasis. Even in the same universities, they have different focuses and evaluation results in the past, at present, and in the future. The advantages of the evaluation of neural networks will not

Table 14. Relative error of elliotsig function for each node selected

No. of nodes	Elliotsig function				Relative error				Mean square error of relative error
					ZP031	ZP032	ZP033	ZP034	
1	8.3832	8.5795	7.3783	8.4259	4.841097	5.032681	-3.04668	5.21886	4.617436
2	8.503	8.4178	8.2194	7.9334	6.339327	3.053103	8.005656	-0.93126	5.349446
3	7.5504	8.387	7.7015	8.3481	-5.57398	2.676041	1.200277	4.247328	3.798385
4	8.3196	8.1721	8.2885	8.4058	4.045709	0.045174	8.913653	4.96786	5.488685
5	7.9459	8.4203	8.0035	8.4748	-0.62782	3.083709	5.168658	5.829501	4.201236
6	7.8867	8.5316	7.9133	8.0636	-1.36818	4.446275	3.9834	0.69462	3.081852
7	8.0463	8.2701	7.6085	7.551	0.627793	1.244918	-0.02177	-5.7065	2.937199
8	7.7209	8.44	7.3295	8.669	-3.44169	3.324882	-3.68793	8.254584	5.114661
9	8.0551	8.0621	8.2036	7.9246	0.737847	-1.30148	7.798039	-1.04115	4.004112
10	8.4612	8.1956	7.4611	8.3083	5.816572	0.332868	-1.95866	3.750324	3.600159
11	8.4455	8.2263	7.4237	8.2682	5.620227	0.708706	-2.45011	3.249573	3.487548
12	8.1396	7.6237	7.3754	8.0928	1.794612	-6.66849	-3.08479	1.059257	3.818618
13	7.7745	7.8591	7.7684	8.5052	-2.77136	-3.78666	2.079366	6.209123	4.02791
14	7.8683	7.4377	8.2082	8.0289	-1.59829	-8.94556	7.858484	0.261302	6.008361
15	8.0069	7.7363	8.0629	8.4604	0.135053	-5.29001	5.949194	5.64968	4.881452
16	7.5064	7.9378	7.7054	8.0972	-6.12425	-2.82319	1.251525	1.114202	3.474356
17	8.6677	8.1739	8.5437	7.7321	8.399081	0.06721	12.26707	-3.445	7.630499
18	7.3218	7.6277	7.9284	8.1774	-8.43287	-6.61953	4.181819	2.115703	5.850113
Mean value	8.0335	8.1166	7.84019	8.1926	0.4678	-0.6344	3.0226	2.3054	4.5207

consider the weight problem. If there are results of the authoritative evaluation in the past, people can easily take advantage of existing large amounts of data to train the network and then conduct the evaluation. In this way, the subjective evaluation of human factors can be eliminated, so it meets the requirement of the application of realistic evaluation, providing a new way of thinking for evaluation of teachers' innovation and entrepreneurship competency in universities.

In this study, an evaluation method of teachers' innovation and entrepreneurship competency based on artificial neural networks is established. However, neural networks have a dependence on the samples, and the approximation and application of the network model are closely related to the typicality of learning samples. Challenges are faced in selecting typical samples from the questions to form the learning sample set. Besides, more examples are required for further verification of the maturity of this method.

DECLARATIONS

Ethical Approval and Consent to participate: Approved.

Consent for publication: Approved.

Availability of supporting data: We can provide the data.

Table 15. Relative error of logsig function for each node selected

No. of nodes	Logsig function				Relative error				Mean square error of relative error
					ZP031	ZP032	ZP033	ZP034	
1	8.5019	8.2325	7.6151	8.137	6.32557	0.784608	0.064953	1.611206	3.287425
2	8.4354	8.2011	7.5162	8.2351	5.493915	0.4002	-1.23463	2.836235	3.158789
3	8.0542	8.1643	7.3952	8.2931	0.726592	-0.05032	-2.82461	3.560513	2.301419
4	8.0336	8.2692	7.8426	8.0491	0.468966	1.2339	3.054379	0.513551	1.683404
5	8.2045	8.2358	7.9212	8.3366	2.606258	0.825008	4.087209	4.103722	3.202305
6	7.9988	8.1047	7.4288	7.9882	0.033754	-0.77996	-2.38309	-0.24694	1.259918
7	8.2039	7.8041	7.8825	7.9665	2.598754	-4.45999	3.578678	-0.51792	3.151197
8	8.3901	8.414	7.9921	7.8688	4.927389	3.006583	5.018858	-1.73795	3.921993
9	8.3813	8.208	7.7716	8.1117	4.817335	0.484672	2.121415	1.295271	2.721202
10	8.2911	8.378	7.8078	7.9879	3.689286	2.56586	2.597095	-0.25069	2.598183
11	8.0632	8.0965	7.9184	8.0423	0.839146	-0.88034	4.050416	0.428635	2.125369
12	8.0901	8.0606	7.8879	7.8698	1.17556	-1.31984	3.649636	-1.72547	2.203463
13	8.2745	8.1079	7.7393	8.2623	3.481684	-0.74078	1.696982	3.175897	2.531647
14	7.9337	8.3415	7.6615	8.2798	-0.78039	2.119017	0.674664	3.394429	2.06619
15	8.3231	7.8718	7.6535	8.1902	4.089481	-3.63118	0.569541	2.275544	2.975392
16	8.1359	8.1503	7.8123	8.0812	1.74834	-0.22171	2.656226	0.914401	1.658125
17	8.5693	7.922	7.573	7.9902	7.168481	-3.01662	-0.48826	-0.22197	3.897909
18	8.0273	8.1377	7.8299	8.0503	0.390178	-0.37596	2.887496	0.528536	1.492529
Mean value	8.2173	8.15	7.736	8.0967	2.766683	-0.22538	1.654276	1.107611	2.568692

Table 16. Results of evaluation of BP neural network of teachers' innovation and entrepreneurship competency in W university (self-evaluation, 34 people, 9-point scale)

No. of teachers	Score of BP network	Score of AHP	Relative error	Rate of error (%)
ZP001	8.1712	8.1712	0.000036	-0.000440
ZP002	8.0611	8.0575	0.003574	0.044356
ZP003	8.0532	8.0513	0.001856	0.023052
ZP004	8.3818	8.3848	-0.00302	-0.036065
ZP005	7.963	7.9579	0.005071	0.063723
ZP006	8.2638	8.2613	0.002533	0.030661
ZP007	8.6213	8.6254	-0.00408	-0.047395
ZP008	7.032	7.0313	0.000717	0.010197
ZP009	7.0729	7.0722	0.000683	0.009658
ZP010	8.2503	8.2480	0.002346	0.028443
ZP011	7.2156	7.2142	0.001402	0.019433
ZP012	7.5978	7.5959	0.001936	0.025487
ZP013	8.5381	8.5365	0.001617	0.018942
ZP014	7.5844	7.5675	0.016874	0.222979
ZP015	8.4885	8.4922	-0.00368	-0.043392
ZP016	8.3839	8.3859	-0.00201	-0.024004
ZP017	7.7434	7.7440	-0.00055	-0.007205
ZP018	8.5579	8.5605	-0.00256	-0.029928
ZP019	7.8127	7.8101	0.002621	0.033559
ZP020	8.1842	8.1855	-0.00132	-0.016138
ZP021	8.4226	8.4199	0.002697	0.032031
ZP022	8.6066	8.6105	-0.00388	-0.045107
ZP023	7.9602	7.9594	0.00077	0.009674
ZP024	8.206	8.2110	-0.00495	-0.060309
ZP025	7.2408	7.2414	-0.00064	-0.008851
ZP026	8.1148	8.1245	-0.00974	-0.119920
ZP027	8.3777	8.3790	-0.00129	-0.015407
ZP028	8.4747	8.4766	-0.00186	-0.022001
ZP029	7.8268	7.8277	-0.00086	-0.010999
ZP030	7.9846	7.9826	0.002031	0.025442
ZP031	7.9988	7.9961	0.002699	0.033753
ZP032	8.1047	8.1684	-0.06371	-0.779955
ZP033	7.4288	7.6102	-0.18135	-2.383091
ZP034	7.9882	8.0080	-0.01977	-0.246941

COMPETING INTERESTS

There is no potential competing interests in our paper. And all authors have seen the manuscript and approved to submit to the journal. We confirm that the content of the manuscript has not been published or submitted for publication elsewhere.

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All authors take part in the discussion of the work described in this paper. These authors contributed equally to this work and should be considered co-first authors.

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