Discriminant Analysis of the Competency of Engineering Teachers in Universities

Xingfeng Liu[1, a] and Tiansong Zhou[1, b]

[1]School of Management, Wuhan University of Technology, P.R.China, 430070

[a]249763651@qq.com, [b]346822862@qq.com

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Abstract. On the basis of introduction of discriminant analysis, analytic hierarchy process is applied to evaluate the competency of engineering teachers in W university to obtain classification data first. Then the discriminant analysis is made by the use of statistical software SPSS19 .0 to evaluate the sample engineering teachers from competency questionnaires in accordance with methods of fisher discriminant classification and stepwise discriminant classification. From the results of discriminant analysis, it is found that compared with the sample results of AHP method, stepwise discriminant analysis is more accurate, which can scientifically classify and discriminate the competency of engineering teachers.

Introduction

When the data of new samples are obtained, people need to determine the type of the known samples. Cases of these belong to problems of discriminant analysis which is also known as “resolution method” [1]. It is classified as a multivariable statistical analysis discriminating ownership of the type in accordance with various eigen-values of the study under defined conditions. The basic principle of discriminant analysis is that one or more discriminant function are established to determine the undetermined coefficients with the large amounts of data of the study, and calculate the judging indexes to determine the type of the samples in accordance with a certain criterion [2].

In accordance with the discriminant criterion, there are methods of distance discrimination, Fisher discrimination, Bayes discrimination and so on. In this paper, methods of Fisher discrimination and Distance discrimination are taken for comparison. In terms of Fisher discrimination, which called canonical discrimination, is based on a linear Fisher discriminant function values to discriminate. The use of the Fisher discrimination requires significant differences of the mean of each set of variables. In other words, the basic idea of this method is a projection. In other words, combination of independent variables of the original R-dimensional space is projected onto a lower D-dimensional space to be classified [3].

The principle of the projection is to minimize the difference of each type and maximize the deviation of different types. The advantage of Fisher discrimination is that there is no restriction for the distribution and variance [4]. Furthermore, the range of application is broad. The basic idea of distance discrimination is as follows: To obtain the center coordinates of samples of each type first, then the distance of the center of gravity of new samples from each category are determined to be classified into the nearest type. The most common distance analysis is Mahalanobis distance. The features of distance discrimination are intuitive, simple and suitable to classify for the conditions that the independent variables are continuous variables. In addition, there is no strict requirement for the type of the distribution of the variables, especially no critical requirement for general equal covariance matrix.

In terms of the verification method of effectiveness of discriminant function, methods of self-validation, external data validation, sample dichotomy, Bootstrap method and cross-validation are usually used to verify the effectiveness of discrimination. However, the method used herein is special and innovative with the use of the data calculated by AHP. Discriminant analysis usually needs to establish the discriminant function by which to do discrimination, so there are mainly two

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discriminant functions, namely linear discriminant function and canonical discriminant function. The canonical discriminant function, which is a linear combination of the original independent variables used in this paper because it is more convenient to describe the relationship between categories through the establishment of a small amount of the canonical variables [5].

Discriminant Sample Data of Competency Evaluation of Engineering Teachers by Means of AHP

Analytic hierarchy process (AHP for abbreviation), proposed by American operational research expert T.L. Saaty in the early 1970s, is a decision-analysis method of hierarchical weight that divides relevant factors down into levels of goals, guidelines, programs and others[6]. On the basis of these levels, qualitative and quantitative analysis is made. According to the requirements of full-time engineering teachers in universities, performance evaluation of engineering teachers are designed to include four guideline layers of quality, knowledge, teaching and research capability and personal feature[7-9]. What's more, these four guideline layers include 24 different indexes forming a complete performance evaluation system of engineering teachers. For the four guideline index, pairwise comparison judgment matrix (U_{ij}) 4×4 can be obtained. Among them, the U_{ij} represents the importance of U_i and U_j which are compared with target value. By means of 1-9 scale method proposed by Satty, the importance of indicators is scale-divided [10]. Apart from that, weighting of indicators are judged by experts according to their backgrounds and experiences. The scale and the results of relative importance of index are obtained from averaging correction, judgment matrix is established. After calculation, judgment matrix has passed consistency test.

$AW=\lambda_{max}W$ 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. Root method is used, calculating method are seen in formula (1-1), formula (1-2) and (1-3). The results are in Table 1.

(1)To calculate the product Mi of the elements of each row of judgment matrix.

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

(2) To calculate n-th root $\overline{WI}$ of $\overline{Wi}$

$$\overline{W_i} = \sqrt[n]{M_i} \tag{1-2}$$

(3) To normalize the vector $\overline{W}=\overline{W1}$, $\overline{W2}$, …, $\overline{Wn}T$

$$W_i = \overline{W_i} \Big/ \sum_{j=1}^{n} \overline{W_j} \tag{1-3}$$

Therefore, W=W1, W2, …, WnT is the feature vector of seeking weight.

Table 1 Stratification weight and total weight

	first level	weight W_i	second level	stratification weight	total weight W_{ij}
U	quality U_1	0.2776	spirit of dedication U_{11}	0.0729	0.0202
			benevolent acceptance U_{12}	0.0706	0.0196
			integrity U_{13}	0.2151	0.0597
			social responsibility U_{14}	0.1320	0.0366
			student orientation U_{15}	0.0706	0.0196
			spread of positive energy U_{16}	0.0688	0.0191

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Table 1, cont.

			role model U_{17}	0.3699	0.1027
	knowledge U_2	0.4668	professional expertise U_{21}	0.3090	0.1442
			research method U_{22}	0.5816	0.2715
			engineering practice U_{23}	0.1095	0.0511
	teaching &scientific research ability U_3	0.1603	study apperception U_{31}	0.0442	0.0071
			teamwork U_{32}	0.2139	0.0343
			theory with practice U_{33}	0.1251	0.0201
			organization of teachingU_{34}	0.0592	0.0095
			innovation and explorationU_{35}	0.1009	0.0162
			cultivation and instruction U_{36}	0.0802	0.0129
			speech expression U_{37}	0.3766	0.0604
	personal feature U_4	0.0953	love for students U_{41}	0.2371	0.0226
			respect to peopleU_{42}	0.1287	0.0123
			enlightenment U_{43}	0.1287	0.0123
			responsibility U_{44}	0.2371	0.0226
			confidence U_{45}	0.0699	0.0067
			persistence U_{46}	0.0699	0.0067
			enterprise U_{47}	0.1287	0.0123

In order to facilitate research, only 7 questionnaires of self-evaluation of engineering teachers are selected as typical samples in W University. Results are calculated according to the weight determined in table 1 and the results of performance evaluation of AHP are shown in Table 2.

Table 2 Results of performance evaluation of AHP in W university (self competency evaluation of 34 engineering teachers)

No. of teachers	sex	age	title	score of evaluation
ZP001	Male	38	lecturer	8.17
ZP002	Male	53	associate professor	8.057526
ZP003	Male	46	associate professor	8.051344
ZP004	Male	36	lecturer	8.384824
ZP005	Male	39	associate Professor	7.957929
ZP006	Male	36	lecturer	8.261267
ZP007	Male	35	lecturer	8.625388
ZP008	Male	36	associate professor	7.031283
ZP009	Male	38	associate professor	7.072217
ZP010	Male	45	professor	8.247954
ZP011	Male	32	lecturer	7.214198
ZP012	Male	43	professor	7.595864
ZP013	Male	48	professor	8.536483
ZP014	Male	44	associate professor	7.567526
ZP015	Male	31	lecturer	8.492185
ZP016	Male	53	associate professor	8.385913
ZP017	Male	55	professor	7.743958
ZP018	Male	38	associate professor	8.560462
ZP019	Male	44	professor	7.810079
ZP020	Male	48	associate professor	8.185521

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Table 2, cont.

ZP021	Male	36	lecturer	8.419903
ZP022	Female	35	lecturer	8.610484
ZP023	Female	48	professor	7.95943
ZP024	Female	33	assistant	8.210952
ZP025	Female	32	lecturer	7.241441
ZP026	Female	44	associate professor	8.124543
ZP027	Female	36	assistant	8.378991
ZP028	Female	32	assistant	8.476565
ZP029	Female	58	professor	7.827661
ZP030	Female	33	lecturer	7.982569
ZP031	Female	34	assistant	7.996101
ZP032	Female	40	associate Professor	8.16841
ZP033	Female	37	lecturer	7.610157
ZP034	Female	34	assistant	8.007975

According to the results above, classification is determined as follows: points below 7.1 are rated as “qualified”; points from 7.1 to 8.1 are rated “good” and points from 8.1 to 9 are rated “excellent”.

Case of Discriminant Analysis of the Competency of Engineering Teachers in W University

In order to facilitate comparison, seven typical engineering teachers are singled out to make discriminant analysis (see table 3). The competency levels of the sample teachers are as follows: The competency level of teacher DP01 and DP02 are qualified; The competency level of teacher DP03 is good; The competency level of teacher DP04 is excellent; Teacher DP05 is excellent in professional knowledge but qualified in quality, personal features, teaching and scientific capability as well; Teacher DP06 is excellent in teaching ability, but qualified in quality and personal features; Teacher DP07 has excellent quality and personal feature, but his teaching and scientific research ability as well as knowledge are qualified.

Table 3 Assessment scores of competency elements of 7 typical engineering teachers

	index \ No. of teachers	ZP01	ZP 02	ZP 03	ZP 04	ZP 05	ZP 06	ZP 07
quality	spirit of dedication	6	7	8	9	7	7	9
	benevolent acceptance	6	7	8	9	7	7	9
	integrity	6	7	8	9	7	7	9
	social responsibility	6	7	8	9	7	7	9
	student orientation	6	7	8	9	7	7	9
	spread of positive energy	6	7	8	9	7	7	9
	role model	6	7	8	9	7	7	9
knowledge	professional expertise	6	7	8	9	9	7	7
	research method	6	7	8	9	9	7	7
	engineering practice	6	7	8	9	9	7	7
teaching & scientific research ability	study apperception	6	7	8	9	7	9	7
	teamwork	6	7	8	9	7	9	7
	theory with practice	6	7	8	9	7	9	7
	organization & teaching	6	7	8	9	7	9	7
	innovation &exploration	6	7	8	9	7	9	7
	cultivation &instruction	6	7	8	9	7	9	7
	speech expression	6	7	8	9	7	9	7
personal	love for students	6	7	8	9	7	7	9

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Table 3, cont.

feature	respect to people	6	7	8	9	7	7	9
	enlightenment	6	7	8	9	7	7	9
	responsibility	6	7	8	9	7	7	9
	confidence	6	7	8	9	7	7	9
	persistence	6	7	8	9	7	7	9
	enterprise	6	7	8	9	7	7	9
First level of U	quality	Q	Q	G	E	Q	Q	E
	personal feature	Q	Q	G	E	Q	Q	E
	teaching &scientific reserach ability	Q	Q	G	E	Q	E	Q
	knowledge	Q	Q	G	E	E	Q	Q

Q=qualified; G=good; E=excellent

Seven typical engineering teachers have been classified as three categories of the qualified. On the basis of data in table 3, SPSS19.0 is used to do discriminant analysis, and the results are shown in Table 4.

Table 4 Seven typical engineering teacher competency determination result

No.	Score of AHP	Level by AHP	Level by AHP	Level by Fisher	Stepwise discrimination Mahalanobis distance	correct signs and false signs （0=C；F=1）	
						Fisher	stepwise
ZP01	6	qualified	3	3.00	3	0	0
ZP02	7	qualified	3	2.00	3	1	0
ZP03	8	good	2	2.00	2	0	0
ZP04	9	excellent	1	1.00	1	0	0
ZP05	7.9344	good	2	2.00	1	0	1
ZP06	7.3206	good	2	2.00	2	0	0
ZP07	7.7463	good	2	3.00	2	1	0
Error rate						28.6%	14.3%

Conclusion

From the error rate in Table 4, the results by means of Stepwise method with error rate of 14.3% are relatively better than those by means of Fisher method with error rate of 28.6%. In detail, stepwise discriminant analysis is more accurate, which can scientifically classify and discriminate the competency of engineering teachers.

However, the error rate by means of Stepwise method is still too big. The reason is due to the traditional classification in which teaching and scientific research ability are mainly emphasized. Therefore, there are many subjective one-sidedness because title appraisal is somewhat different from the competency appraisal in which quality, teaching and scientific research ability as well as personal feature are evaluated at the same time. The advantage of discriminant analysis method is that it is objective and scientific for the classification of engineering teachers because it can avoid subjective influence from the people. If the discriminant analysis method is used in the newly-employed engineering teachers, it will provide the quantitative guidance and reference for the competency evaluation of newly-introduced and distinguished talents.

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