An information content model of teachers' teaching ability improvement in higher school based on information axiom

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Abstract

One way to ensure the teaching quality of institutes of higher learning is by improving university teachers' teaching ability is an important approach to. This paper proposes an information content model of teachers' teaching ability improvement based on information axiom. Accurate and reliable, this paper analyses factors than influence the teaching ability and constructs an evaluation indicator system by Analytical Hierarchy Process. It works out the calculation model of information content targeting at different indicators with the help of fuzzy theory and information axiom. After weight is taken into account, it acquires the comprehensive information content model and measures teachers' teaching ability. Case study proves that the model and the algorithm are effective.

Keywords: Higher education; teaching ability improvement; information content; information axiom; evaluation model

1 Introduction

Teaching ability is an important element to evaluate the quality of teachers. It is important to ensure the teaching quality of the school by improving teacher ability. The improvement of teaching ability is in line with the demand of teachers as well as the sustainable development of education sector. Thus, there is a necessity to conduct accurate and reliable evaluation on teaching ability [1-3]. However, many factors need to be taken into account because the evaluation is a complicated and fuzzy decision-making process..

Many researchers have studied how to improve university teachers' teaching ability and made progress about this issue [4-8]. However, these methods are more or less limited. In comparison, this paper bases itself on fuzzy theory [9-10] and information axiom [11-13] and studies from the perspective of fuzzy information content. The information content model of teachers' teaching ability improvement in higher school based on information axiom is effective enough to evaluate teachers' teaching ability.

2 evaluation index system of improving university teachers' teaching ability

Improving university teachers' teaching ability there are certain principles to follow in indicator selections.

(1) Scientific principle: These indicators should be able to reflect real situation of teachers' teaching ability in order to analyse from a multiple perspective.

(2) Principle of completeness: indicators should avoid bias and single-perspective. They should reflect the teaching ability systematically.

(3) Practical principle: indicators should be representative and hold significance. Both quantitative indicators and qualitative ones should be able to be analysed effectively.

According to these principles, we can construct an evaluation indicator system of university teachers' teaching ability improvement, as is shown in Table 1.

TABLE 1 Evaluation indicator system of university teachers' teaching ability improvement

System layer	first class index	second class index
evaluation index system of improving university teachers' teaching ability C	basic professional ability C_1	enrichment of teaching content C_{11}
		rationality of teaching progress C_{12}
		correct teaching attitude C_{13}
		advanced teaching method C_{14}
		flexibility of teaching method C_{15}
		student satisfaction C_{16}
		supervisory review satisfaction C_{17}

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evaluation index system of improving university teachers' teaching ability C	teaching reform ability C_2	planning ability of professional curriculum C_{21}
		innovation ability of teaching reform C_{22}
		number of teaching reform projects C_{23}
		number of teaching reform publications C_{24}
		number of teaching reform awards C_{25}
	innovation practice ability C_3	number of curriculum design C_{31}
		number of graduation projects C_{32}
		qualified rate of graduation projects C_{33}
		number of internships in enterprise C_{34}
		students' participation in scientific and technical competitions C_{35}
		number of scientific and technical awards C_{36}
	integration of teaching and researching C_4	integration of teaching and researching C_{41}
		teaching expansion with the help of researching C_{42}
		number of scientific research projects C_{43}
		number of scientific papers and patents C_{44}

3 An information content model of teachers' teaching ability improvement in higher school based on information axiom

3.1 INFORMATION CONTENT CALCULATION MODEL OF INDICATORS FOR POINT VALUE

Some evaluation indicators of teachers' teaching ability have accurate value of a quantity. Suppose the value of a quantity about indicator j of teacher i is $v_{ij}(C)$. It is necessary to apply the benchmark $v_j^{\otimes}(C)$ of indicator j to standardization so that the information content has unified measurement. If indicator j is a positive indicator, then the standardized value of a quantity $v_{ij}(C)$ about indicator j of teacher i is $v_{ij}^*(C)$:

$$v_{ij}^*(C) = v_{ij}(C) / v_j^{\otimes}(C) = v_{ij}(C) / \max_{1\le i\le m}\left(v_{ij}(C)\right) \tag{1}$$

m Refers to the number of teachers of higher school.

If indicator j is an adverse indicator, then the standardized value of a quantity $v_{ij}(C)$ about indicator j of teacher i is $v_{ij}^*(C)$:

$$v_{ij}^*(C) = v_j^{\otimes}(C) / v_{ij}(C) = \min_{1\le i\le m}\left(v_{ij}(C)\right) / v_{ij}(C) \tag{2}$$

According to information axiom, the exponential distribution density function or the calculation model of the point-value information content $I_{ij}^d(C)$ is:

$$I_{ij}^d(C) = \log_2 e^{1-v_{ij}^*(C)} \tag{3}$$

3.2 INFORMATION CONTENT CALCULATION MODEL OF INDICATORS FOR INTERVAL VALUE

Some indicators have value of a quantity. But they are not in the form of point value, but the interval value. The value of a quantity about indicator j of teacher i is

$$V_{ij}(C) = \left[v_{ij}^{let}(C), v_{ij}^{rig}(C)\right].$$

If it is a positive indicator, then the standardized value $V_{ij}^*(C)$ is:

$$V_{ij}^*(C) = \left[v_{ij}^{*-let}(C), v_{ij}^{*-rig}(C)\right] = \left[\frac{v_{ij}^{let}(C)}{\max\limits_{1\le i\le m}\left(v_{ij}^{rig}(C)\right)}, \frac{v_{ij}^{rig}(C)}{\max\limits_{1\le i\le m}\left(v_{ij}^{rig}(C)\right)}\right] \tag{4}$$

The information content calculation model $I_{ij}^d(C)$ of indicators is:

$$I_{ij}^d(C) = \log_2 e^{1-\frac{1}{2}\left(\frac{v_{ij}^{let}(C)}{\max\limits_{1\le i\le m}\left(v_{ij}^{rig}(C)\right)} + \frac{v_{ij}^{rig}(C)}{\max\limits_{1\le i\le m}\left(v_{ij}^{rig}(C)\right)}\right)} \tag{5}$$

If indicator j is an adverse value, the standardized value of a quantity $V_{ij}^{*}(C)$ about indicator j of teacher i is:

$$V_{ij}^{*}(C)=\left[v_{ij}^{*-let}(C),v_{ij}^{*-rig}(C)\right]=\left[\frac{\min\limits_{1\le i\le m}\left(v_{ij}^{let}(C)\right)}{v_{ij}^{rig}(C)},\frac{\min\limits_{1\le i\le m}\left(v_{ij}^{let}(C)\right)}{v_{ij}^{let}(C)}\right] \tag{6}$$

The information content calculation model $I_{ij}^{d}(C)$ of indicators is:

$$I_{ij}^{d}(C)=\log_2 e^{1-\frac{1}{2}\left(\frac{\min\limits_{1\le i\le m}\left(v_{ij}^{let}(C)\right)}{v_{ij}^{rig}(C)}+\frac{\min\limits_{1\le i\le m}\left(v_{ij}^{let}(C)\right)}{v_{ij}^{let}(C)}\right)} \tag{7}$$

3.3 INFORMATION CONTENT CALCULATION MODEL OF INDICATORS FOR QUALITATIVE DESCRIPTION

In the indicator system, some indicators are fuzzy that can also be described by fuzzy language. Therefore, fuzzy language is transformed to interval value falling between [0, 1] to represent evaluation value of corresponding indicators. The evaluation value can be available through comprehensive rating, expert consultation and statistical analysis. 0-1 ratio scale is adopted to transform and the results are shown in Table 2.

TABLE 2 Fuzzy language transformation of qualitative description

Transformed value of a quantity of indicators	qualitative description	
	Positive indicator	Adverse indicator
0	very poor	Excellent
0.2	Poor	Good
0.4	Ok	Medium
0.6	Medium	Ok
0.8	Good	Poor
1.0	Excellent	Very poor
0.1,0.3,0.5,0.7,0.9	In between	

Suppose the transformed value of a quantity of qualitative description about indicator j of teacher i is $\varphi_{ij}(C)$, the information content calculation model $I_{ij}^{d}(C)$ of corresponding indicator is:

$$I_{ij}^{d}(C)=\log_2 e^{1-\varphi_{ij}(C)} \tag{8}$$

3.4 INFORMATION CONTENT CALCULATION MODEL OF INDICATORS FOR FUZZY MEMBERSHIP DEGREE

In the indicator system, some value of a quantity needs to be expressed by fuzzy membership degree. For one thing, fuzzy membership degree can be available through the correlation with the optimal value. If the membership degree about indicator j of teacher i is u_{ij}, then optimal value is u_{ij}^{0}, then the information content calculation model $I_{ij}^{d}(C)$ of indicator is:

$$I_{ij}^{d}(C)=\log_2 e^{\left|u_{ij}^{0}-u_{ij}\right|} \tag{9}$$

For another, the fuzzy membership degree can be expressed by fuzzy membership function. Suppose the function about indicator j of teacher i is $f_{ij}(v(x))$, when it is a positive indicator, the information content calculation model $I_{ij}^{d}(C)$ of indicator is:

$$I_{ij}^{d}(C)=\log_2 e^{1-f_{ij}(v(x))} \tag{10}$$

When it is an adverse indicator, the information content calculation model $I_{ij}^{d}(C)$ of indicator is:

$$I_{ij}^{d}(C)=\log_2 e^{f_{ij}(v(x))} \tag{11}$$

3.5 AN INFORMATION CONTENT MODEL OF TEACHERS' TEACHING ABILITY IMPROVEMENT IN HIGHER SCHOOL BASED ON INFORMATION AXIOM AND THE ALGORITHM

Suppose there are n first-class indicators and n_k second-class indicators in the k-th first-class indicator and suppose they have the same significance, then the information content calculation model $I_i^d(C)$ for i-th institutes of higher learning is:

$$I_i^d(C)=\frac{1}{n}\sum_{j=1}^{n}\left(\frac{1}{n_k}\sum_{k=1}^{n_k}I_{ijk}^{d}(C)\right) \tag{12}$$

If these indicators have different weight, and the weight of the second-class indicators is w_{jk}, that of the first-class indicators is w_j, then the information content calculation model $I_i^d(C)$ for i-th institutes of higher learning is:

$$I_i^d(C)=\sum_{j=1}^{n}\left(w_j*\left(\sum_{k=1}^{n_k}\left(w_{jk}*I_{ijk}^{d}(C)\right)\right)\right) \tag{13}$$

According to the physical meaning of information content, the less information content the evaluation object contains, the better the object is. Thus, based on the evaluation standard for teachers' teaching ability improvement, there is:

$$I_r^d(C)=max\left(I_1^d(C),\cdots,I_i^d(C),\cdots,I_m^d(C)\right) \tag{14}$$

Thus, the r-th institute of higher learning has the best evaluation result in terms of teachers' teaching ability improvement

4 Case study and test

This paper takes the evaluation on teachers' teaching ability of an institute of higher education during the recruitment as an example to prove that the information content model is effective. Based on the evaluation indicator system and through survey, we can get the data of three qualified teachers, as are shown in Table 3.

TABLE 3 Data of teachers for evaluation to improve university teachers' teaching ability

first class index	second class index	Value of a quantity			Type of value of a quantity	Type of indicator
		Teacher A	Teacher B	Teacher C		
basic professional ability C_1	enrichment of teaching content C_{11}	0.92	0.92	0.95	Fuzzy membership degree	Positive
	rationality of teaching progress C_{12}	0.93	0.92	0.93	Qualitative description	Positive
	correct teaching attitude C_{13}	0.90	0.95	0.90	Qualitative description	Positive
	advanced teaching method C_{14}	0.85	0.85	0.90	Qualitative description	Positive
	flexibility of teaching method C_{15}	0.90	0.85	0.85	Qualitative description	Positive
	student satisfaction C_{16}	0.90-0.94	0.90-0.94	0.94-0.96	Interval value	Positive
	supervisory review satisfaction C_{17}	0.83-0.87	0.88-0.92	0.83-0.87	Interval value	Positive
teaching reform ability C_2	planning ability of professional curriculum C_{21}	0.92	0.93	0.95	Qualitative description	Positive
	innovation ability of teaching reform C_{22}	0.95	0.93	0.85	Qualitative description	Positive
	number of teaching reform projects C_{23}	3	2	2	Point value	Positive
	number of teaching reform publications C_{24}	3	4	2	Point value	Positive
	number of teaching reform awards C_{25}	1	1	1	Point value	Positive
innovation practice ability C_3	number of curriculum design C_{31}	4	4	2	Point value	Positive
	number of graduation projects C_{32}	8	10	10	Point value	Positive
	qualified rate of graduation projects C_{33}	0.875	1.00	0.90	Point value	Positive
	number of internships in enterprise C_{34}	2	3	3	Point value	Positive
	students' participation in scientific and technical competitions C_{35}	4	4	3	Point value	Positive
	number of scientific and technical awards C_{36}	3	4	3	Point value	Positive
integration of teaching and researching C_4	integration of teaching and researching C_{41}	0.85	0.90	0.85	Fuzzy membership degree	Positive
	teaching expansion with the help of researching C_{42}	0.85	0.90	0.85	Fuzzy membership degree	Positive
	number of scientific research projects C_{43}	4	4	5	Point value	Positive
	number of scientific papers and patents C_{44}	6	10	8	Point value	Positive

Subject the value of a quantity to standardization. The results are shown in Table 4.

TABLE 4 Value of a quantity of indicators after standardization for improving university teachers' teaching ability

second class index	Standardized value of a quantity		
	Teacher A	Teacher B	Teacher C
enrichment of teaching content C_{11}	0.920	0.920	0.950
rationality of teaching progress C_{12}	0.930	0.920	0.930
correct teaching attitude C_{13}	0.900	0.950	0.900
advanced teaching method C_{14}	0.850	0.850	0.900
flexibility of teaching method C_{15}	0.900	0.850	0.850
student satisfaction C_{16}	0.90-0.94	0.90-0.94	0.94-0.96
supervisory review satisfaction C_{17}	0.83-0.87	0.88-0.92	0.83-0.87
planning ability of professional curriculum C_{21}	0.920	0.930	0.950
innovation ability of teaching reform C_{22}	0.950	0.930	0.850
number of teaching reform projects C_{23}	1.000	0.667	0.667
number of teaching reform publications C_{24}	0.750	1.000	0.500
number of teaching reform awards C_{25}	1.000	1.000	1.000
number of curriculum design C_{31}	1.000	1.000	0.500
number of graduation projects C_{32}	0.800	1.000	1.000
qualified rate of graduation projects C_{33}	0.875	1.000	0.90
number of internships in enterprise C_{34}	0.667	1.000	1.000
students' participation in scientific and technical competitions C_{35}	1.000	1.000	0.750
number of scientific and technical awards C_{36}	0.750	1.000	0.750
integration of teaching and researching C_{41}	0.850	0.900	0.850
teaching expansion with the help of researching C_{42}	0.850	0.900	0.850
number of scientific research projects C_{43}	0.800	0.800	1.000
number of scientific papers and patents C_{44}	0.600	1.000	0.800

According to information content calculation model of different indicators, we can get the corresponding information content, as in Table 5.

TABLE 5 Information content of indicators for improving university teachers' teaching ability

second class index	information content of indicators		
	Teacher A	Teacher B	Teacher C
enrichment of teaching content C_{11}	0.115	0.115	0.072
rationality of teaching progress C_{12}	0.101	0.115	0.101
correct teaching attitude C_{13}	0.144	0.072	0.144
advanced teaching method C_{14}	0.216	0.216	0.144
flexibility of teaching method C_{15}	0.144	0.216	0.216
student satisfaction C_{16}	0.115	0.115	0.072
supervisory review satisfaction C_{17}	0.216	0.144	0.216

planning ability of professional curriculum C_{21}	0.115	0.101	0.072
innovation ability of teaching reform C_{22}	0.072	0.101	0.216
number of teaching reform projects C_{23}	0	0.480	0.480
number of teaching reform publications C_{24}	0.361	0	0.721
number of teaching reform awards C_{25}	0	0	0
number of curriculum design C_{31}	0	0	0.721
number of graduation projects C_{32}	0.289	0	0
qualified rate of graduation projects C_{33}	0.180	0	0.144
number of internships in enterprise C_{34}	0.480	0	0
students' participation in scientific and technical competitions C_{35}	0	0	0.361
number of scientific and technical awards C_{36}	0.361	0	0.361
integration of teaching and researching C_{41}	0.216	0.144	0.216
teaching expansion with the help of researching C_{42}	0.216	0.144	0.216
number of scientific research projects C_{43}	0.289	0.289	0
number of scientific papers and patents C_{44}	0.577	0	0.289

According to Table 5, we can get the evaluation result of these 3 teachers. The sequence is

$$\boldsymbol{I} = (0.191, 0.102, 0.216).$$

Teacher B has the smallest information content, which means that under the current indicator system, teacher B is the most qualified one for the job.

5 Conclusions

This paper proposes an information content model of teachers' teaching ability improvement based on information axiom. Through the study of relevant influencing factors, it constructs an evaluation indicator system following certain rules. Based on fuzzy theory and information axiom, it works out the calculation model of information content targeting at different indicators. It then measures teachers' teaching ability and suggests for improving the teaching quality. The model proposed in this paper is simple and clear with convenient calculation. Case study proves that the model and the algorithm are effective.

References

[1] Fan Zeheng. Technology selection and strategy of promoting college teachers' teaching ability [J]. Research in Higher Education,2009,30（8): 89-94.
[2] Liu Qiang, Dai Qixun. On The Current Evaluation System of Teaching Quality Under the Mass Higher Education [J]. JOURNAL OF JIANGSU UNIVERSITY(HIGHER EDUCATION STUDY EDITION),2003,25（2): 31-34.
[3] Zhang Yingqiang. Professionalization of Teachers in Universities and Enhancement of Their Teaching Ability [J]. MODERN UNIVERSITY EDUCATION, 2010, (4):35-39.
[4] Ma Hong. Using grey correlation to evaluate teaching quality [J]. Journal of wuhan university of technology, 2010,32（15): 181-184.
[5] Sun Xiaoling, Wang Ning, Liang Yan. A Method of Teaching Quality Evaluation Making Use of BP Neural Networks [J]. COMPUTER SIMULATION,2010,27（11): 314-317.
[6] Liu Wei, Sun Lin. Classroom teaching quality assessment based on support vector machine [J]. JOURNAL OF HEFEI UNIVERSITY OF TECHNOLOGY(NATURAL SCIENCE),2010,33（7): 968-971.
[7] He Yinye, Shi Dandan. Evaluation of secondary vocational teachers' teaching abilities Based on AHP [J]. Adult Education,2014(5):83-85.
[8] Mao Chenglin, Sun Liyan, He Gang Strategy Research on Improving Teaching capacity in Higher Education [J]. Vocational education,2013(5):172.
[9] Ti-chun Wang, Ai-jun Yang, Shi-sheng Zhong. MULTI-ATTRIBUTE EXTENSION FUZZY OPTIMIZED DECISION-MAKING MODEL OF SCHEME DESIGN[J]. Tehnički vjesnik/Technical Gazette. 2014,21(2) : 239-247.
[10] Wang Guiping, Jia Yazhou, Zhou Guangwen. Evaluation Method and Application of CNC Machine Tool's Green Degree Based on Fuzzy-EAHP. JOURNAL OF MECHANICAL ENGINEERING, 2010, 46(3): 141-147
[11] Dunbing Tang, Guangjun Zhang, Sheng Dai. Design as integration of axiomatic design and design structure matrix [J]. Robotics and Computer-Integrated Manufacturing, 2009, 25(3):610~619.
[12] Wang Tichun,Chen Bingfa,Bu Liangfeng. Multi-attribute Optimal Selection Model of Large-Scale Hydraulic Turbine Scheme Design Based on Information Axiom [J]. Journal of Nanjing University of Aeronautics & Astronautics, 2011,43(6):822-826.
[13] Osman Kulak, M. Bülent Durmuşoğlu, Cengiz Kahraman. Fuzzy multi-attribute equipment selection based on information axiom [J]. Journal of Materials Processing Technology, 2005, 169 (3):337-345.

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