

Fuzzy Comprehensive Evaluation Software of Teaching Quality Based on Entropy

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Abstract

The present teaching evaluation models are researched on and the evaluation criteria is designed automatically from the perspectives of experts and students. And then that is made to be a kind of scientific and reasonable criteria. By combining the approach weighted entropy and fuzzy comprehensive evaluation, the present model proposes a teaching comprehensive evaluation model. This software model solves some problems in conducting quantitative analysis of teaching equality. And at the same time, it avoids subjectivity in directly assigning weight to the results. A case study shows that this software model can improve fuzzy comprehensive evaluation with reliability, accuracy as well as objectivity. The model will be suggested to optimize teaching management and improve teaching quality.

Keywords: *evaluation of teaching quality, entropy method, evaluation index system, fuzzy comprehensive evaluation method*

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1. Introduction

The School teaching is the basic approach of training qualified personnel and achieving educational purposes, so teacher's teaching quality evaluation is the forceful measures and important guarantee to achieve this approach, which is the important force on promoting educational improvement and the important means on examining educational quality. By scientific educational evaluation, we can take scientific and rational evaluation on teacher's teaching quality and level. It brings positive incentives and correct guiding, and promotes the change and reformation of teaching content, teaching concepts and teaching methods, also it improves teaching quality. Through rigorous educational evaluating, decision-making information could be provided for the construction of teaching staff and reliable basis for teacher's performance, promotion salary, recognition awards, and so on. At the same time, we can establish perfect and scientific teaching evaluation models step by step, consummate teaching evaluation mechanism, and make reasonable, fair conclusion.

At present, the main means of educational evaluation is AHP [1] (Analytic Hierarchy Process). In building the judgment matrix, AHP adopts a scale method of 1 ~ 9 scales to analysis each pairwise factors for all layers of factors, but there are some problems: having few obvious otherness in judgment, having not a easy method to determine the scale of judgment, having a large number of computation, and the concrete values that man-made can't receive a convincing result of the teaching quality assessment; The teaching evaluation model based on neural network [2] need to set concrete parameters, inter evaluation indexes, and then it can output the teaching effect, but its shortcoming is that in order to get concrete parameters it needs large-scale data to repeat testing, and also, it needs a large number of computation and it is not convenient. The teaching evaluation model based on fuzzy comprehensive evaluation [3, 4] leads fuzzy method into the teaching evaluation, and the teaching evaluation is a complicated process with multi-factor and multi-indicator. We can't distinguish it in right or not, while fuzzy logics is a method in precise but incomplete information, whose greatest feature is that it can naturally deal with the fuzziness of the thinking of human. But it still adopts the method man-made to set the index weights, and its computation is subjectivity. Based on studying the currently algorithms, the author learns from the paper's method [5], leading information entropy

into the teaching quality evaluation, combining fuzzy comprehensive evaluation, and then makes the calculation quantify, the result more scientific, more reasonable, more accurate.

Though the teaching evaluation algorithm which is scientific, rigorous and reasonable is very important, the right of teaching evaluation result doesn't only base on teaching evaluation algorithm, but also it must has a teaching evaluation model which is scientific, reasonable and comprehensive. At present, there are some problems on teaching evaluation model in domestic colleges and universities [6], such as overemphasizing the supervisory role in evaluation, and ignoring the role of introduction and improvement; not having a perfect content of evaluation, not reflecting the unity of teaching and learning; unilaterally exaggerating the role of teaching. Based on the existing teaching evaluation models home and abroad, the author has designed a scientific and reasonable teaching evaluation model, and makes the result of teaching evaluation more reliable, more accurate and more objective and fair, basing on scientific teaching evaluation system and reasonable teaching evaluation model. Ricardo Queirós [7] presents a tool called Petcha that acts as an automated Teaching Assistant in computer programming courses. Based on previous work [8, 9, 10] and other researchers' work [11, 12], a prototype software is implemented.

2. Research Method

2.1. Design The Index of Teaching Quality Evaluation

At present, the teaching evaluation index in domestic colleges and university only involves conventional indexes, such as teaching attitude, school discipline, teaching content, teaching methods and so on. These indexes only can unilaterally monitor classroom teaching, but they can't qualitatively analysis and assessment the teacher's overall quality and innovation capability. While in developed countries represented by the United States, England and Germany [13], the teaching quality evaluation firstly think highly of the teacher's innovation capability, and emphases on the teacher's ability of guiding students to find, analyze and solve problems. Secondly, they attach importance on the teacher's overall quality, assessing the teacher's background, knowledge, feedback, communication and self-learning. So in this article the indexes of teaching quality evaluation doesn't only evaluate teacher's teaching, but also include evaluation on teachers' innovation capability and personal qualities. Through this work, we can make up a part of the problems of evaluation index setting unscientific to get a more objective evaluation on teachers' teaching quality.

In addition, the practice of New Zealand university in the teaching quality assessment shows that [14] the teaching evaluation expresses the reunion between the quality of the "teaching" and "learning". It requires the teaching evaluation index doesn't only include the evaluation for classroom teaching, but also the evaluation for practical teaching such as students' practice teaching and laboratory teaching. what's more, the evaluation for students is needed such as the students' effort in classroom and autonomous learning ability.

Table 1. The Evaluation Indexes and Standars From Experts

Indexes	The contents and standards
Teaching attitude	Serious, Attention to teaching feedback, Can do both teaching and learning
School discipline	Comply with the teaching discipline, No instructional error, accidents, major accidents
Teachers' overall quality	Assess the teacher's background, qualifications, knowledge, skills, feedback, communication and self-learning
Innovation capability	Assess the teacher' s innovation capability, Emphases on the teacher' s ability of guiding students to identify, analyze and solve problems
Classroom structure classroom teaching	Teaching link is well organized, Classroom structure is compact and reasonable
Teaching methods	Scientific and accurately explain the basic concepts, principles, theories, prominent emphasis, thoroughly explain the difficulty, integrate theory with practice,
Teaching expression	Appropriate, Freely use it, Can stimulate students' interest, Variety of teaching methods, Diagnostic teaching, Stimulate thinking
Teaching practice	Standard mandarin, Strong proper arrangement, Reasonably design writing on the blackboard, Properly body language
Course examination and evaluation	Include the contents of arrangements for the experimental teaching, practice teaching and so on, Amount of hours
Students' status	Manners of exams, Contents of exam, Feedback of students' test scores
	Students love the discipline, classroom atmosphere, interest in learning and level of effort, autonomous learning or not

In order to express the relationship between “teaching” and “learning”, in this article, teaching quality evaluation is divided into teachers and students. The evaluation indexes and standards from experts and students are designed as shown in table 1 and Table 2.

Table 2. The Evaluation Indexes and Standards From Students

Indexes	The contents and standards
Teaching attitude	Serious, Attention to teaching feedback, Can do both teaching and learning
School discipline	Comply with the teaching discipline, No absences, tardiness, early over class, Stringent requirements of students
Teaching Contents	Scientific and accurately explain the basic concepts, principles, theories, prominent emphasis, thoroughly explain the difficulty, Can integrate theory with practice, Can do the unified between basic and advanced
Teaching methods	Appropriate, Freely use it, Can stimulate students' interest, Variety of teaching methods, Diagnostic teaching, Stimulate thinking
Teaching expression	Standard mandarin, Strong proper arrangement, Reasonably design writing on the blackboard, Properly body language
Operations and counseling	Seriously layout, correcting homework, Regularly counseling and answers to doubts, Seriously answer the students' various issues
Teaching effectiveness	Through seriously study the course, can understand and grasp the theory, basic knowledge and basic skills
Self-expression	Students love the discipline, classroom atmosphere, interest in learning and level of effort

2.2. Establish The Index of Teaching Quality Evaluation

According to the indexes of table 1 and table 2, we have established the indexes of teaching quality evaluation by experts and students. The result of teaching quality evaluation is composed of the evaluation for experts and students, which is the average of this two results, and it reflects the unity of “teaching” and “learning”, and also reflects that we pay much attention to fair and equal between “teaching” and “learning”. Shown in Figure 1.

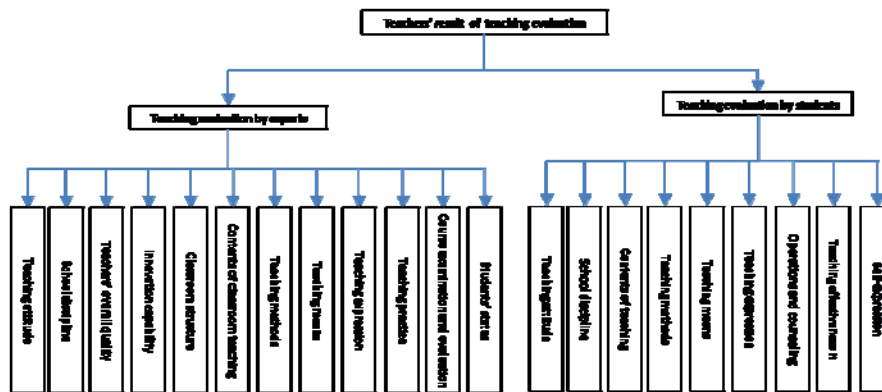


Figure 1. The Indexes of Teachers' Teaching Quality Evaluation

3. The Teaching Quality Evaluation Model Based on Weighted Entropy

3.1. Theoretical Basis

In the year 1948, Shannon posted a paper named “A mathematical theory of communication [15]”, and proposed the concept of information entropy.

$$H(x) = -\sum P(a_i) \log_2 P(a_i)$$

it is used to express the average information content which was offered by every message after the output of the source, or the average uncertainty before the output of the source. Information entropy expresses the degree of ordering of system, it can measure the size of the amount of information, more information a certain index includes, more important in making a strategic decision. According to the thought of entropy, how much

the information that we get and the quality of it are the determinants of decision-making's accuracy and reliability, while entropy is an ideal scale, it can objectively determine the weights based on the information from every evaluation index, so we can evaluate the degree of ordering and utility of the information that we get by information entropy, thus avoid the weight of each index caused anthropogenic interference, and make the evaluation result more actual, this method is weighted entropy methods.

The principle of calculating weight of teaching quality indicators by using the theory of information entropy(weighted entropy methods) is:

In 1957, a paper [16] raised the maximum entropy principle, and defined the entropy is

$$H(x) = -k \sum_{i=1}^n P_i \log P_i \quad (1)$$

In the (1) equation, $0 \leq P_i \leq 1$ ($i = 1, 2, \dots, n$), and $\sum_{i=1}^n P_i = 1$, k is proportion function.

When P_i ($i = 1, 2, \dots, m$) is more nearly equal, the entropy is greater, and the uncertainty that the impact of the teaching quality index R_i for the result of evaluation is greater. When P_i ($i = 1, 2, \dots, m$) is equal, the maximum entropy is: $H_{\max} = \log m$.

After normalizing, the information entropy can be expressed:

$$e_i = -\frac{1}{\log m} \sum_{j=1}^m r_{ij} \log r_{ij} \quad (2)$$

When $r_{i,j}$ ($j = 1, 2, \dots, m$) takes equal to the value, the maximum value of entropy e_i is 1, so the value of e_i meet $0 \leq e_i \leq 1$. Because when the value of entropy is maximum, the contribution of the teaching quality indicator to the result of evaluation is least, so we can determine the weight of teaching quality indicator R_i by $1 - e_i$ the metric. Therefore, after normalizing them, we get the weight of teaching quality factors R_i

$$\phi_i = (1 - e_i) / |n - \sum_{i=1}^c e_i| \quad (3)$$

In the (3) equation, $0 \leq \phi_i \leq 1$, and $\sum_{i=1}^n \phi_i = 1$.

3.2. The Software Model of Teaching Quality Evaluation

Because the teacher's teaching quality evaluation involves more contents, the level of knowledge, cognitive abilities and personal preferences of assessor directly affect the evaluation index, so it is difficult to completely exclude the bias caused by human factors. Moreover, evaluation indicators are generally qualitatively described, and they have distinctive fuzzy features, so the author lead to fuzzy comprehensive evaluation method. At the same time, in order to avoid the subjectivity of using the weight to directly give assignment, the author lead to the approach of weighted entropy. The calculation of the fuzzy comprehensive evaluation model of teachers' teaching quality on the basis of weighted entropy is shown in chart 2:

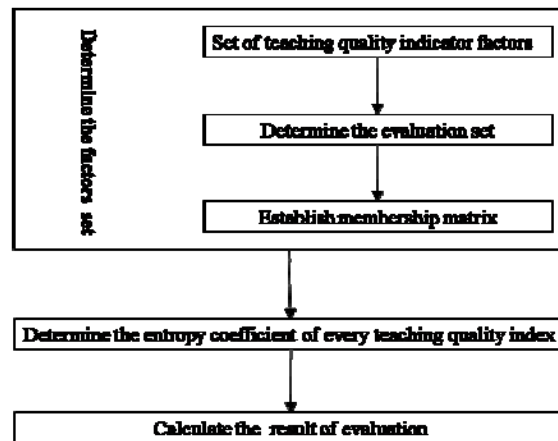


Figure 2. The Software Model of Teaching Quality

3.3. Determine the Factor's Set

(1) The factors set of teacher's teaching quality indicator is $L = \{l_1, l_2, \dots, l_c\}$, the indicator factors of teacher's teaching quality are $L_1 = \{\text{teaching attitude, School discipline, Innovation capability, Teachers' overall quality, classroom teaching, Teaching practice, Classroom structure, ...}\}$, $L_2 = \{\text{Teaching attitude, School discipline, Contents of teaching, Teaching methods, Teaching expression, ..., Self-expression}\}$.

(2) Determining the evaluation set according to teacher's teaching quality indicator factors, $V = \{v_1, v_2, \dots, v_m\}$, that is, $V = \{\text{excellent, competent, basis competent, failed}\}$.

(3) Establishing membership matrix. In the fashion of filling out evaluation cards by experts and students, we can find the membership of the comments that the factors belong to different levels. Taking any teaching index factors l_1 as an example, three experts think this teacher is excellent, the ten think competent, the five think basis competent, two person think failed, then the l_1 to the membership of excellent is 0.15; the membership of competent is 0.5, the membership of basis competent is 0.25, the membership of failed is 0.1, similarly, we can get the membership of other teaching quality indicator factors, and the fuzzy evaluation matrix is:

$$R = \begin{pmatrix} r_{11} & \cdots & r_{1m} \\ \vdots & \ddots & \vdots \\ r_{c1} & \cdots & r_{cm} \end{pmatrix}$$

3.4. Determining the Entropy Coefficient of Each Teaching Quality Index

After normalizing the relative importance of teaching quality factors R_i , we expressed it as the following information entropy:

$$e_i = -\frac{1}{\log m} \sum_{j=1}^m r_{ij} \log r_{ij} \quad (4)$$

We normalize it and get the weight of teaching quality indicator factors R_i :

$$a_i = (1 - e_i) / |c - \sum_{i=1}^c e_i| \quad (5)$$

In the (5) equation, $0 \leq a_i \leq 1$, and $\sum_{i=1}^c a_i = 1$.

According to the degree of support which every factor of teaching quality indicator to the every indicator of evaluation set, we calculated the weight of every teaching quality indicator factor through information entropy. According to the equation (4), we calculated the vector $E = (e_1, e_2, \dots, e_c)$, then basing on the equation(5) we get the weight vector of every teaching quality indicator factor is $A = (a_1, a_2, \dots, a_c)$.

3.5. Result of Evaluation

Based on

$$B = AR \quad (6)$$

We get the final fuzzy evaluation vector. When normalizing B , we get $B' = (b'_1, b'_2, \dots, b'_m)$, among of it $b'_j = \frac{b_j}{\sum_{j=1}^m b_j}$, ($j = 1, 2, \dots, m$)

We set the evaluation set is $V' = \{v'_1, v'_2, \dots, v'_r\}$, they represent a different level of evaluation, and then quantify them, finally through the equation

$$S = \sum B'V' \quad (7)$$

We get the results of teaching quality evaluation from experts and students, which are and , then the result of teacher's teaching quality evaluation is the average of experts' evaluation and students' evaluation.

$$S = (S_1 + S_2) / 2 \quad (8)$$

4. Case Study and Software Implementation

We take Mr. Jia for example, who is a teacher of computer software institute of an institutions of higher learning, to verify the accuracy of the model. First of all, we chose 20 experts and 50 students and then evaluated Jia's teaching quality from the perspective of the index of evaluation for experts and students, the evaluation set is $V = \{\text{Excellent, Competent, Basically competent, Failed}\}$. Based on the evaluation result from experts and students, we get the membership of the teaching quality indicators on the factors of V . As shown in the following chart, the table 3 is from the perspective of experts, the table 4 is from students.

Table 1. The Perspective of Experts

Excellent	Competent	Basically C	Failed
0.4	0.5	0.05	0.05
0.3	0.5	0.15	0.05
0.2	0.45	0.2	0.15
0.15	0.4	0.3	0.15
0.35	0.45	0.1	0.1
0.15	0.6	0.15	0.1
0.3	0.5	0.15	0.05
0.2	0.7	0.1	0.1
0.15	0.45	0.3	0.1
0.1	0.4	0.4	0.1
0.15	0.5	0.2	0.15
0.35	0.55	0.05	0.05
0.2	0.4	0.35	0.05

Table 2. The Perspective of Students

Excellent	Competent	Basically C	Failed
0.22	0.58	0.16	0.04
0.24	0.44	0.2	0.12
0.16	0.38	0.3	0.16
0.2	0.4	0.3	0.1
0.36	0.48	0.14	0.02
0.24	0.44	0.16	0.16
0.24	0.44	0.16	0.16
0.2	0.6	0.18	0.02
0.14	0.58	0.24	0.02

Next, based on equation 4 and 5, we can calculate the weight vector of the index factors of the teaching quality:

$$A_{experts} = (0.1267, 0.0831, 0.0303, 0.0675, 0.0951, 0.0828, 0.1202, 0.0517, 0.0654, 0.0505, 0.1325, 0.0613)$$

$$A_{students} = (0.1705, 0.0574, 0.0384, 0.0576, 0.1692, 0.0502, 0.2008, 0.2026)$$

The fuzzy evaluation vector is:

$$B_{experts} = (0.2528, 0.5057, 0.1591, 0.0824) \quad B_{students} = (0.2241, 0.5287, 0.1933, 0.0539)$$

Then, we set the scope of the evaluation of factors of the evaluation set: (7.5, 1] represents excellent, (5, 7.5] is competent, (2.5, 5] is basically competent, (0, 2.5] is failed, and make the midpoints of the ranges as evaluation criteria, they are 8.75, 6.25, 3.75, 1.25. Based on equation 7, we respectively get the results of the teachers' teaching quality evaluation from the perspective of experts and students:

$$S_{experts} = 6.0575 \quad S_{students} = 6.0723 \quad S = 6.0649$$

since $S \in (5, 7.5]$, so the result of teaching quality evaluation for Jia is competent.

The evaluation system is designed for estimating the teaching equality. Figure 3 shows that the membership matrix is very important and can be received by a set of complicated calculation. And in the next paragraph, we will show our implementation of the software. Our implementation use Chinese language and does not include all of the functions. We just show how our proposed method can be implemented. But we intend to add components with these functions where possible.

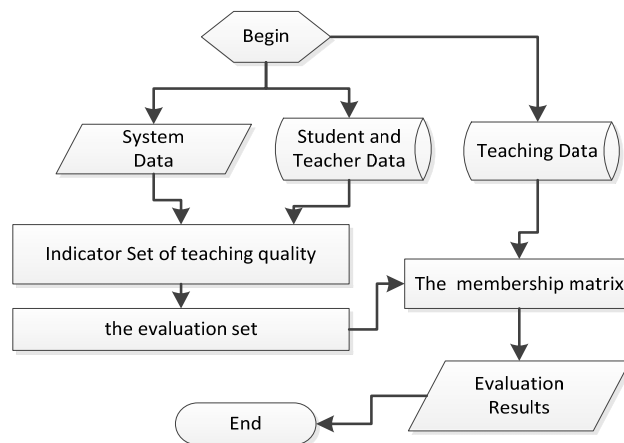


Figure 3. Flow chart of the Evaluation Software



Figure 4. Setting Evaluation Indexes

Figure 5. The Evaluation Results of Teaching Quality

This approach has been investigated by applying it to implement evaluation software written in Java under Microsoft Windows. Our current implementation (depicted in Figure 3, 4) is implemented to be applied to teaching evaluation system. To this end, our implementation extends existing evaluation software infrastructure. Figure 4, 5 shows the our software's Graphical User Interface (GUI). The evaluation software GUI is composed in Java to ensure portability to fixed and mobile platforms. The Software modules include: Scores distribute results, course scores, teacher's average scores and parameters setting.

5. Conclusion

Through researching the index of teachers' teaching quality evaluation, the author designs more scientific indexes. And on this basis the author raises the fuzzy comprehensive evaluation algorithm for the teaching quality which is based on weighted entropy method, this methods doesn't require artificial weights assignment, so the result is more reasonable. Next, the author will collect a large number of experimental data to verify the accuracy of the model. Additionally, the model still has some shortcomings (such as in the process of evaluation, there is a restriction: $r_{ij} > 0, \log m \neq 0$), we will further improve the algorithm to make the result of teachers' teaching quality evaluation more objective and reasonable.

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