

Application of Case-Based Decision Theory in Evaluation of College Teachers' Classroom Performance

Fei Du

School of Management, Guangzhou College of South China University of Technology, Guangzhou, 510800, China

Keywords: Student evaluation, Teachers' classroom performance, Higher education, Case based decision theory (cbdt)

Abstract: This paper is preliminary research involving the application of case-based decision theory in evaluation of college teachers' classroom performance. A new evaluation model is provided by considering the previous cases, i.e., the evaluation in past semesters should be combined by considering the similarity between courses and classes. We develop the entire computational procedures for the proposed method, and use a numerical example to illustrate our method. Findings show that similarity is critical factor, because similarity is the weight of each case. Teachers should teach similar courses for similar classes. Universities should adopt the new evaluation model to guide teachers in teaching of Excellent Courses, and elimination of fluke psychology, in order to train better students.

1. Introduction

Education quality is the lifeline of institutions of higher education. Along with the gradual deepening and energetical practice of undergraduate teaching quality and reformation project, many institutions of higher education in China are constructing and exploring inside education and teaching quality supervision and insurance system. Student evaluation of teacher performance is the important component of this system. Numerous studies demonstrate that students can identify the most significant dimensions of effective and efficient teaching [1] [8] [10] [18] [22] [25] [26] [30], the only group of individuals who routinely experiences all facts of a teacher's classroom behaviours are the students themselves.

In order to supervise and manage teacher's classroom teaching quality in university effectively, the evaluation index system of teacher's classroom teaching quality under modern information technology environment in the university is established. The evaluation of teacher's classroom teaching quality from students will influence the ranking and wages.

There is an enormous amount of literature on student evaluations of instruction, literally thousands of papers according to Marsh and Dunkin [24]. Cashin writes that there are probably more studies of student evaluations than of all the other means used to evaluate college teaching combined [7]. Furthermore, many studies focus on the index system of teacher's classroom teaching quality under modern information technology environment in the university [4][42]. Generally, index system contain four indexes, namely, teaching attitude, content of courses, teaching method, teaching effectiveness. Then, many studies focus on the method to evaluate teachers' performance

considering multiple attributes [6] [17] [19] [37] [38] [39] [41] [43], such as factor analysis method, fuzzy mathematics, statistical analysis, cloud model.

However, in fact, students of different majors have different characteristics which influence the students' evaluation. For example, students majoring in accountancy may prefer the way to do more exercises, while students majoring in marketing may prefer cases study. Then one teacher teaches the same course to different majors previously mentioned will receive different comments, and two teachers with the same teaching method will receive different comments if they teach different majors mentioned before. But, it is difficult to decide which is better than which, because both of these are very effective. In addition, Students in different grades prefer different teaching styles. For example, college freshmen may prefer the knowledge in the book, while senior university students may prefer extra-curricular knowledge. Therefore, it is not fair to evaluate teacher' classroom performance with one semester score because it has something to do with the arrangement of curriculum.

Consequently, it is necessary to consider the comments from the previous semester in evaluation of teacher' classroom performance in this semester with weighted average method. In traditional evaluation theory, decision makers evaluate each act by aggregating the scores of attributes, or turning to the experts for help. In fact, the decision makers would use the similar cases to evaluate each act. The case based decision theory model introduced in this paper actually provides a new perspective in evaluation of college teachers' performance, i.e., the evaluation in past semesters should be combined by considering the similarity between courses and classes which is the focus in this study. We aim to (1) give the similarity function between courses and classes, and (2) provide the model in evaluation of college teachers' classroom performance.

To the best of our knowledge, this paper appears to be the first attempt to study this topic. The rest of this paper is organized as follows. Literature review is presented in Section 2. Section 3 provides the analytical model in evaluation of college teachers' classroom performance. Numerical illustrations are provided in Section 4. Finally, the last section shows the implications for researchers and management, as well as the directions for future research.

2. Literature Review

Two distinct streams of related literature should be considered, evaluation of university teacher's teaching quality and Case-based decision theory.

2.1 Evaluation of Univeristy TEACHER's Teaching Quality

Evaluation of university teacher's teaching quality is an important issue in education industry. Research on student evaluations of teaching and the factors which may affect those dates back to the 1920s and the pioneering work of Remmers[3][33][34][35]. In his series, Remmers confronted some of the major issues in the area of student evaluation research, such as whether the judgments of students agree with those of peers and alumni. Spencer and Flyr report that the first teacher rating scale was published in 1915 [36]; Marsh notes that student evaluation procedures were introduced at several major US universities in the 1920s [23].

Numerous studies stated that feedback from student ratings can help to improve instruction [5][8][23][25][26][30]. Furthermore, many studies focus on the index system of teacher's classroom teaching quality under modern information technology environment in the university [4][42]. Generally, index system contains four indexes, namely, teaching attitude, content of courses, teaching method, teaching effectiveness. Then, many studies focus on the method to evaluate teachers' performance considering multiple attributes [6] [17] [19] [37] [38] [39] [41] [43], such as factor analysis method, fuzzy mathematics, statistical analysis, cloud model.

We should note that all the previous papers mentioned above focus on the evaluation of teachers' performance in one semester. In fact, students of different majors have different characteristics which influence the students' evaluation. The case based decision theory model introduced in this paper actually provides a new perspective in evaluation of college teachers' performance, i.e., the evaluation in past semesters should be combined by considering the similarity between courses and classes. To the best of our knowledge, this paper appears to be the first attempt to study this topic.

2.2 Case-Based Decision Theory

Itzhak Gilboa and David Schmeidler proposed a new approach of decision making under uncertainty, named case based decision theory (CBDT) [12]. The theory describes the decision rule that choose a best act which has maximal sum of the utility in past similar cases. Formally, a set of problems P , a set of acts A , and R is the set of outcomes, P and A decide R . A case is a triple of the form $(p, a, r) \in C = P \times A \times R$, and the memory of the decision maker M , consists n cases. We view a case c as an act profile, using the act a to solve the problem p , and the result is the r . The theory also defined a utility function $u(r)$ and a similarity function $s(p, q) \in [0, 1]$. The former transfers the outcome to utility, and the latter describes the similarity between the problems past and previous. When the decision maker (DM) faces a new problem p , he or she will choose the act a which can

$$\text{maximize the } U(a), \text{ where } U(a) = U_{p,M}(a) = \sum_{(q,a,r) \in M} s(p,q)u(r).$$

Case-based decision makers learn from the past similar cases. The richer the experience is, the more accurately the decision make. Many studies focus on the set of cases[2][40] and similarity [13][15]. Blonski proposed that it not only consists of the decision maker's own experiences, but also the indirect information told by other[2], such as people, publications, consultants and so forth, just because of the social nature of man, and the indirect information play an increasingly important role in the Network Era. In addition, humans generally live in groups just like most primates. Renkema et al. stated that people have a greater preference to conform to the opinions of others when mortality is salient, suggested that conforming to the group is a means to buffer the fear that may otherwise arise in existentially threatening situations[32]. Offerman and Sonnemans examined whether individuals learn from experience and/or by imitation, and conducted an experiment whose results indicated that people learn both from experience and by imitating successful others[28]. In addition, a method of differentiating the irrespective cases and the heuristic cases is proposed with the case-based decision method based on threshold[40]. Du and Liu used Dempster-Shafer theory of evidence to extend the case based decision theory, and ordered the acts by aggregating the evaluations of each act by everyone around the decision makers[9].

This theory (CBDT) can explain some phenomena in financial market[14], and gets some applications in product theory[16][20] and consumer theory. Meyer et al. researched the process of individual decision making over time, including two major areas: one is that how current choices are influenced by the history of previous choices, another is that how choices may be made to exploit expectations about options available in the future[27]. Gilboa and Pazgal presented a discrete model in which the consumer makes choices based on his or her past experience[11]. Pape and Kurtz evaluate the efficacy of CBDT as an account of human decision-making on this set of problems[31]. The findings of the paper [29] substantiate a predominant significantly higher validity of CBDT compared to the classical criteria and reinforcement learning. The results obtained by Kinjo and Sugawara [21] demonstrate better performance of the case-based models than models based on traditional expected utility theory regarding both statistical model selection and one-step-ahead prediction.

Although there are a mass of papers published on the topic of CBDT, few of them use CBDT to the evaluation of university teacher's teaching quality, which will be addressed in our current study.

3. The Model

3.1 Base Setting

We provides a new perspective in evaluation of college teachers' performance, i.e., the evaluation in past semesters should be combined by considering the similarity between courses and classes. Generally, one teacher may teach several courses for different classes with different majors, and students of different majors have different characteristics which influence the students' evaluation. However, to facilitate model formulation in the following subsections, we assume that (1) one teacher only teach one course for one class, (2) the similarity only is related with courses and classes, and (3) the influences from these two factors are independent. We first model the case sets and similarity, and then describe the evaluation model which can eliminate the effect of subjective judgment.

3.2 Case Matrix

Itzhak Gilboa and David Schmeidler proposed a concept of memory matrix to describe the memory of decision makers, including all the past similar experiences[12]. In this paper, we still use the concept to describe the evaluation scores in previous semesters. We suppose that each teacher have been teaching for n semesters, and only teach one subject $S_i (i=1,2,\dots,n)$ for one class $C_i (i=1,2,\dots,n)$ in one semester, and the teacher receives the evaluation score $E_{ii} (i=1,2,\dots,n)$ in each semester. Then we give the case matrix in formal below:

$$\begin{matrix} & C_1 & C_2 & \cdots & C_n \\ \begin{matrix} S_1 \\ S_2 \\ \vdots \\ S_n \end{matrix} & \begin{bmatrix} E_{11} & - & \cdots & - \\ - & E_{22} & \cdots & - \\ \vdots & \vdots & \cdots & \vdots \\ - & - & \cdots & E_{nn} \end{bmatrix} \end{matrix}$$

3.3 Similarity

Accordingly, one teacher teaches the same course to different majors previously mentioned will receive different comments, and two teachers with the same teaching method will receive different comments if they teach different majors mentioned before. In this paper, we adopt the function $sim((S_i, C_i), (S_j, C_j))$ to represent the similarity among the cases. The weights of attributes have significant impact on the similarity, then will influence the validity of decision. For simplicity, we assume the influences from courses and classes are independent. Then the similarity function is as follows,

$$sim((S_i, C_i), (S_j, C_j)) = \sigma_s sim(S_i, S_j) + \sigma_c sim(C_i, C_j) \quad (1)$$

where, σ_s is the weight of course, and σ_c is the weight of class.

Similarity of classes

We suppose that one class has m attributes, and the similarity function is as follows,

$$sim(C_i, C_j) = \frac{\sum_{k=1}^m \omega_k x_{ik} \cdot \omega_k x_{jk}}{\sqrt{\sum_{k=1}^m (\omega_k x_{ik})^2 \sum_{k=1}^m (\omega_k x_{jk})^2}} \quad (2)$$

where, ω_k is the weight of attribute k.

In this paper, we suppose that one class has 6 attributes as follows,

First attribute is major. In fact, students of different majors have different characteristics which influence the students' evaluation. For example, students majoring in accountancy may prefer the way to do more exercises, while students majoring in marketing may prefer cases study.

Second attribute is the proportion of boys and girls in the class. Generally, boys and girls have different characteristics which influence the students' evaluation. For example, boys may prefer passion, and girls may prefer humor.

Third attribute is number of students in the class. Class-scale has a great influence on classroom environment. Then students in large classes and small classes probably give different evaluations to teachers.

Forth attribute is the grade of the class. Students in different grades prefer different teaching styles. For example, college freshmen may prefer the knowledge in the book, while senior university students may prefer extra-curricular knowledge.

Fifth and sixth attributes are pass rates and average scores in previous semesters respectively. The two attributes reflect the study atmosphere of the class from the side. Students in different classes with different study atmosphere will give different evaluations to teachers.

3.3.1 Similarity of Courses

Course similarity calculation aims at quantitatively computing the cross degree of the knowledge points two courses contain. Previous papers studied courses similarity using text mining [44]. In this paper, we obtain the similarity of courses by experience without influence on the analysis results.

3.3.2 Similarity of Cases

Accordingly, we get the similarity of cases as follows,

$$sim((S_i, C_i), (S_j, C_j)) = \sigma_s \frac{\sum_{k=1}^m \omega_k x_{ik} \cdot \omega_k x_{jk}}{\sqrt{\sum_{k=1}^m (\omega_k x_{ik})^2 \sum_{k=1}^m (\omega_k x_{jk})^2}} + \sigma_c sim(C_i, C_j) \quad (3)$$

3.4 Evaluation Model

In current semester, one teacher teaches one course S_{n+1} for one class C_{n+1} , and this teacher receives score $E_{n+1, n+1}$. The evaluation should consider the previous scores based on the similarity. The evaluation model is as follows,

$$E = \frac{E_{n+1, n+1} + \sum_{i=(1, 2, \dots, n)} E_{ii} sim((S_{n+1}, C_{n+1}), (S_i, C_i))}{n+1} \quad (4)$$

4. Numerical Studies

To show the evaluation model described in the previous section, we present a numerical example. We assume that there are 5 teachers in School of Management at one University.

4.1 Case Matrix and Attributes of Subjects and Classes

Based on the model provided before, we describe the case matrix of each teacher as follows.

Table 1 Case Matrix And Attributes of Subjects and Classes

Teacher	Case matrix	Subjects	Classes
A	$ \begin{matrix} & C_1 & C_2 & C_3 & C_4 \\ S_1 & \left[\begin{array}{cccc} 80 & & & \\ & 90 & & \\ & & 85 & \\ & & & 88 \end{array} \right] \\ S_2 \\ S_3 \\ S_4 \end{matrix} $	$S_1 = S_2 = S_3,$ S_4	$C1:(major1, 1/2, 36, 1th, 85\%, 88);$ $C2:(major1, 1/1, 45, 2th, 75\%, 78);$ $C3:(major2, 1/3, 40, 2th, 95\%, 80);$ $C4:(major2, 2/1, 60, 1th, 90\%, 82)$
B	$ \begin{matrix} & C_1 & C_2 & C_3 & C_4 & C_5 & C_6 \\ S_1 & \left[\begin{array}{cccccc} 75 & & & & & \\ & 80 & & & & \\ & & 90 & & & \\ & & & 85 & & \\ & & & & 85 & \\ & & & & & 95 \end{array} \right] \\ S_2 \\ S_3 \\ S_4 \\ S_5 \\ S_6 \end{matrix} $	$S_1 = S_2 = S_4,$ $S_3 = S_5 = S_6$	$C1:(major1, 1/2, 36, 1th, 85\%, 88);$ $C2:(major1, 1/1, 45, 2th, 75\%, 78);$ $C3:(major2, 1/3, 40, 2th, 95\%, 90);$ $C4:(major1, 2/1, 60, 1th, 90\%, 82);$ $C5:(major2, 1/3, 40, 2th, 92\%, 80);$ $C6:(major2, 2/1, 60, 1th, 90\%, 85)$
C	$ \begin{matrix} & C_1 & C_2 & C_3 \\ S_1 & \left[\begin{array}{ccc} 90 & & \\ & 80 & \\ & & 85 \end{array} \right] \\ S_2 \\ S_3 \end{matrix} $	$S_1 = S_2 = S_3$	$C1:(major1, 1/1, 36, 1th, 85\%, 88);$ $C2:(major1, 2/1, 45, 2th, 75\%, 78);$ $C3:(major2, 1/1, 40, 2th, 95\%, 80)$
D	$ \begin{matrix} & C_1 & C_2 & C_3 & C_4 \\ S_1 & \left[\begin{array}{cccc} 90 & & & \\ & 80 & & \\ & & 95 & \\ & & & 85 \end{array} \right] \\ S_2 \\ S_3 \\ S_4 \end{matrix} $	$S_1 = S_2,$ $S_3 = S_4$	$C1:(major1, 2/1, 60, 2th, 85\%, 90);$ $C2:(major1, 1/1, 30, 1th, 75\%, 88);$ $C3:(major1, 2/1, 30, 3th, 95\%, 87);$ $C4:(major1, 2/1, 60, 1th, 90\%, 85)$
E	$ \begin{matrix} & C_1 & C_2 \\ S_1 & \left[\begin{array}{cc} 90 & \\ & 85 \end{array} \right] \\ S_2 \end{matrix} $	$S_1,$ S_2	$C1:(major1, 1/3, 40, 2th, 88\%, 89);$ $C2:(major2, 2/1, 36, 3th, 85\%, 81)$

4.2 Similarity

In current semester, each teacher teaches one subject for one class as follows.

Table 2 New Subject And Class for Each Teacher

Teacher	Subjects	Classes
A	S_5	$C5:(major2, 1/1, 50, 2th, 85\%, 86)$
B	S_7	$C7:(major3, 2/1, 40, 3th, 75\%, 78)$
C	S_4	$C4:(major1, 1/1, 30, 1th, 90\%, 85)$
D	S_5	$C5:(major2, 1/2, 50, 2th, 80\%, 80)$
E	S_3	$C3:(major1, 1/1, 46, 3th, 75\%, 81)$

In this paper, we give the similarity of subjects immediately. Furthermore, based on the model provided before, we give the similarity as follows, here we suppose that the weights of attribute are the same. To clearly show the similarity model, we give the concrete calculation process for teacher A.

Example:

First, major and grade should become quantifiable. According to the major of the class which taught by teacher A in this semester, we set major2 to 1, and major1 to 0. Similarly, we set grade2 to 1, and other to 0.

Second, other attributes should be normalized. In this paper, we introduce the method of Maximize Normalization, i.e., $x' = x/X_max$.

Then, we get the value of attributes as follows,

Table 3 Value of Attributes after Normalization

	major	proportion of boys and girls	number of students	grade	pass rates	average scores
C1	0	0.25	0.60	0	0.89	1.00
C2	0	0.50	0.75	1	0.79	0.89
C3	1	0.17	0.67	1	1.00	0.91
C4	1	1.00	1.00	0	0.95	0.93
C5	1	0.50	0.83	1	0.89	0.98

Based on the model provided before and the assumption of same weight, we get the similarity model as follows,

$$sim(C_i, C_j) = \frac{\sum_{k=1}^m x_{ik} \cdot x_{jk}}{\sqrt{\sum_{k=1}^m (x_{ik})^2 \sum_{k=1}^m (x_{jk})^2}}$$

Then, we get the similarity of classes for teacher A as follows,

Table 4 Similarity of Classes for Teacher a

	C1	C2	C3	C4	C5
C5	0.743	0.886	0.984	0.865	1.000

After that, we get the similarity of subjects and classes.

Table 5 Similarity of Subjects and Classes for Each Teacher

Teacher	Similarity of Subjects	Similarity of Classes
A	$S_1 \ S_2 \ S_3 \ S_4$ $S_5 \ [0.75 \ 0.75 \ 0.75 \ 1]$	$C_1 \ C_2 \ C_3 \ C_4$ $C_5 \ [0.743 \ 0.886 \ 0.984 \ 0.865]$
B	$S_1 \ S_2 \ S_3 \ S_4 \ S_5 \ S_6$ $S_7 \ [0.9 \ 0.9 \ 1 \ 0.9 \ 1 \ 1]$	$C_1 \ C_2 \ C_3 \ C_4 \ C_5 \ C_6$ $C_7 \ [0.680 \ 0.731 \ 0.657 \ 0.756 \ 0.659 \ 0.757]$
C	$S_1 \ S_2 \ S_3$ $S_4 \ [1 \ 1 \ 1]$	$C_1 \ C_2 \ C_3$ $C_4 \ [0.998 \ 0.844 \ 0.741]$
D	$S_1 \ S_2 \ S_3 \ S_4$ $S_5 \ [1 \ 1 \ 0.8 \ 0.8]$	$C_1 \ C_2 \ C_3 \ C_4$ $C_5 \ [0.824 \ 0.698 \ 0.643 \ 0.677]$
E	$S_1 \ S_2$ $S_3 \ [0.5 \ 1]$	$C_1 \ C_2$ $C_3 \ [0.871 \ 0.858]$

Accordingly, we get the similarity of cases as follows, here we suppose that the weights of subjects and classes are same.

Table 6 Similarity of Cases for Each Teacher

Teacher	Similarity of Cases						
A		(S1,C1)	(S2,C2)	(S3,C3)	(S4,C4)		
	(S5,C5)	0.747	0.818	0.867	0.932		
B		(S1,C1)	(S2,C2)	(S3,C3)	(S4,C4)	(S5,C5)	(S6,C6)
	(S7,C7)	0.790	0.816	0.828	0.828	0.830	0.878
C		(S1,C1)	(S2,C2)	(S3,C3)			
	(S4,C4)	0.999	0.922	0.870			
D		(S1,C1)	(S2,C2)	(S3,C3)	(S4,C4)		
	(S5,C5)	0.912	0.849	0.322	0.339		
E		(S1,C1)	(S2,C2)				
	(S3,C3)	0.686	0.929				

4.3 Evaluation

In current semester, each teacher's score is given, and according to the model provided before and the similarity of cases, we get the new evaluation score.

Table 7 Scores with Different Method

Teacher	Score in this semester	Score by new model	Average Score
A	83	74.416	85.200
B	91	73.486	85.857
C	79	79.164	83.500
D	86	73.469	87.200
E	90	76.895	88.333

Based on the model provided in this paper, we get the ranking order of the five teachers is:

$$C \succ E \succ A \succ B \succ D.$$

If we use the traditional method which aggregates the cases directly, then the ranking order is $E \succ D \succ B \succ A \succ C$. If we only use the score received in this semester, then the ranking order is $B \succ E \succ D \succ A \succ C$.

As a conclusion, teacher B receives the highest score in this semester, while teacher C gets the first prize based on the new model which considers the previous cases. From Table 6, we find that similarity is critical factor in this evaluation model, because similarity is the weight of each case. For example, one teacher received 100 scores in second semester. If the similarity is very low, then the contribution of the score in second semester for the new evaluation score is very small. In other words, teachers should teach similar courses for similar classes.

5. Conclusions and Future Research

This paper is a preliminary research involving the application of case-based decision theory in evaluation of college teachers' classroom performance. A new evaluation model is provided by considering the previous cases, i.e., the evaluation in past semesters should be combined by considering the similarity between courses and classes.

The contributions of the paper are mainly reflected in three aspects. First, this study enriches the knowledge of evaluation of college teachers' classroom performance by introducing case-based decision theory. Different from previous studies, previous cases, i.e., scores in previous semester, are considered. Second, similarity function is provided. We give 6 attributes of class, i.e., major, proportion of boys and girls in the class, number of students in the class, grade of the class, pass

rates and average scores in previous semesters. Third, this study may enrich the knowledge of case based decision theory with extending application scenarios.

In terms of industry practice, this study may provide valuable implications for teachers and universities. Findings show that similarity is a critical factor, because similarity is the weight of each case. For example, one teacher received 100 scores in second semester. If the similarity is very low, then the contribution of the score in second semester for the new evaluation score is very small. In other words, teachers should teach similar courses for similar classes. In fact, each teacher's spirit is limited, and should spend more effort on one or two courses in order to achieve better teaching results. Universities should adopt the new evaluation model to guide teachers in teaching of Excellent Courses, and elimination of fluke psychology, in order to train better students.

Several limitations, which could be streamlined into interesting directions for further research, are identified. First, we suppose that one teacher only teaches one course for one class. Several courses and several classes could be more realistic. Second, we suppose that the similarity only is related with courses and classes, and the influences from these two factors are independent. Other factors and mutual influence should be considered in further research. Third, the impact of number of semesters should be considered in further research. Although more challenges will be encountered in adhering to these directions, such initiatives would yield potentially interesting insights.

6. Acknowledgment

The research is supported by the Excellent doctoral program of Guangzhou College of South China University of Technology(YB180003),and Education and Teaching Reform Project of Guangzhou College of South China University of Technology (JY-201401).

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