RESEARCH ON THE EVALUATION OF TEACHERS' TEACHING QUALITY BASED ON △S EQUATION

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ABSTRACT

The teaching quality evaluation of college teachers is an important indicator of school evaluation, performance assessment and teacher promotion. However, the existing evaluation methods are only limited to the formal evaluation of teaching behavior, and have not achieved objective, reasonable and scientific evaluation results. The purpose of this paper is to propose a △S equation of the state of the teaching system from the point of view of the teaching system's operation process. On this basis, a Markov process evaluation method for teachers' teaching quality is established. The research results show that the application of the △S equation of the teaching system to the evaluation of teaching behavior and teaching effect has its own characteristics, and the key lies in the reasonable selection of the △S equation and the the combination of Markov analysis can effectively achieve the evaluation goal of teachers' teaching quality.

KEYWORDS

Teaching Quality Evaluation, △S Equation, Markov Analysis

1. INTRODUCTION

The evaluation of teachers' teaching quality is an important task of teaching management in colleges and universities. Teaching quality is the main work quality of teachers in colleges and universities, and it is also one of the important indicators to evaluate the quality of running schools in colleges and universities. It plays an important role in college evaluation, teacher work evaluation, and teacher promotion. For a long time, in the formulation of various educational policy documents and school education and teaching management systems, the quality of teachers' teaching has been placed in an important position. However, in the actual management and evaluation implementation, the rationality, objectivity and scientificity of teachers' teaching evaluation have not been fundamentally resolved, which results in that the evaluation of teachers' teaching quality is limited to formalized management modes such as workload statistics (Sun,2011). With the continuous deepening of information technology in teaching management in colleges and universities, the management and evaluation of teachers' teaching quality have been networked and digitalized. At present, various types of network teaching management systems have been developed, and some teaching quality management software has been put into practice (Zhang, 2014). However, a prominent problem is that the existing teaching quality evaluation is either based on the evaluation of students, peers and leaders, or the evaluation results of students' test scores, ignoring the process management of teaching quality, and failing to achieve teaching quality evaluation the real purpose (Fan, 2005).

Therefore, how to evaluate the teaching quality of teachers in colleges and universities, so as to build a reasonable and scientific management system of college teaching quality, is an urgent problem to be solved in college education and teaching management. Teaching quality management of college teachers is a systems engineering. Usually, a mathematical model of teaching evaluation is constructed in the network teaching management system. The existing research is to establish an evaluation model based on multiple teaching factors (Zhang, 2011). The function of this comprehensive evaluation teaching quality model is to reveal the activity law of the teaching quality system. However, in the specific implementation, it is found that only the calculation method of weighted summation cannot achieve the purpose of teaching management and evaluation (Si, 2008). Because teaching quality is affected by variousfactors inside and outside the teaching system, teaching quality management and evaluation need to link various factors and establish a

mathematical model to reveal the quantitative relationship between them (Wang, 2008). As the researchers argue: "No matter what system is studied, no quantitative analysis is possible until a mathematical model describes the relationship between the physical system and external inputs."(Wang, 2004). In fact, not only is this the case with physical systems, but teaching, as an artificial system, cannot do in-depth quantitative analysis without revealing the mathematical relationship between the internal factors of teaching activities and the external environment, and it is impossible to reveal any mechanism of teaching activities. Of course, teaching, as a behavioral interaction system between teachers and students, is much more complex than the general physical system, and there is also a lack of necessary data accumulation in education and teaching management. Therefore, we try to establish the relationship between the variables of the teaching system in a very definite form. It is difficult to describe. However, according to the actual situation of the teaching information management system in colleges and universities, a teaching quality big data analysis system can be established. Based on the collection, processing, diagnosis and evaluation of teachers' teaching quality data, the process quality of teachers' teaching is evaluated by selecting an effective mathematical model. This is also the original intention and purpose of this study.

2. METHODS OF EVALUATING THE QUALITY OF TEACHERS' TEACHING WORK

The evaluation of the quality of teachers' teaching work is usually called teaching evaluation, which is different from the evaluation of the comprehensive teaching quality of a school. Generally speaking, the network assessment of comprehensive teaching quality of college teachers adopts the following methods:

$$K_m = \sum_{i=1}^{n} a_i k_i \tag{1}$$

In the formula (1), K_m represents the comprehensive teaching quality level; k_i represents the ratio of the hours of each course and various teaching links to the total number of hours; a_i is the weighting coefficient. The evaluation of the quality of teachers' teaching work is different from this. It focuses on teaching activities, and is an evaluation of teachers' behaviors and the resulting effects in actual teaching activities. Its purpose is to help teachers overcome weak links and continuously improve their teaching level. Generally speaking, the basic form of teaching quality evaluation is to divide according to the direct object of evaluation, namely behavior evaluation method and effect evaluation method.

2.1 Teaching Behavior Evaluation Method

Teaching behavior evaluation method is a widely used teaching quality evaluation method in colleges and universities. Teaching behavior evaluation method takes teachers' behavior in teaching activities as the direct evaluation object. Teachers' teaching behavior is usually determined by teaching attitude, teaching ability, teaching method and so on. Teaching behavior evaluation method can be divided into: ①Student evaluation; ②Peer evaluation; ③Leader evaluation; ④Self-evaluation and other methods (Zhang, 2008). There have been many research results in the evaluation of teaching behavior, and many successful experiences have been widely used in the practice of education and teaching management. However, there are certain limitations in the quality of teachers' teaching based on teaching behavior: first, it is difficult to quantify teachers' teaching behavior; second, there are constraints of human feelings and competitive environment, so it is difficult to realize the objectivity, rationality and scientificity of teaching evaluation.

2.2 Teaching Effectiveness Evaluation Method

The effect evaluation method of the quality of teaching work takes the final effect of the teaching work, that is, the students' academic performance as the information source, and takes the students' behavior change, ability growth, and learning level improvement as the quality level of teaching work after a stage of learning. It is a method of evaluating teachers' teaching work through the effect of teaching.

2.3 The Relationship between the Two Evaluation Method

The teaching behavior evaluation method directly takes the teacher's work as the evaluation object, and the effect evaluation method evaluates the teacher's teaching work from the students' learning effect. It can be considered that the evaluation method of teaching quality effect is an indirect method. However, in the teaching process, students' learning is under the guidance of teachers, and students' gain and improvement through course learning is the most direct and authoritative basis for reflecting the teaching effect. Although some indicators can be established around teaching work to judge the quality of teachers' behavior, the most fundamental criteria for establishing these indicators are how to promote students' learning and the teaching effect. Therefore, in this sense, it can be considered that the teaching effect method is a direct method, and the behavior method is an indirect method.

There are still some technical difficulties in evaluating the quality of teachers' teaching work from the learning effect of students. Mainly, student learning outcomes are determined by multiple factors. As mentioned earlier, in addition to the teacher's work, the quality of management, internal and external environmental influences, and the student's learning base all have an impact on the final outcome of learning. In addition, it is also a question whether the students' performance based on the teaching evaluation can reflect the real level of the students. The existence of these difficulties hinders the application of the effect method, but some researchers believe that "students' learning effect can fully reflect the teaching effect" (Wei, 2009). Because the evaluation method of teaching behavior often exists that the benevolent sees benevolence, the wise sees wisdom, and lacks objectivity, and the effect evaluation method has its unique advantages in this respect. Therefore, it is the real meaning of college teachers' teaching quality evaluation to seek appropriate ways, overcome the above difficulties, and constantly improve the effect evaluation method of teaching quality so that it can be used in actual teaching management. This paper solves this problem by establishing the △S equation of the teaching system.

3. MATHEMATICAL MODEL OF TEACHER TEACHING PROCESS EVALUATION

3.1 △S Equations for Teaching Systems

In the network system of teaching management and evaluation in colleges and universities, the state change of the teaching system is an important information, which is related to the quality of teachers' teaching work, the quality of teaching management, and the internal and external environment (conditions) of the teaching system. The mathematical expression for this relationship is as follows:

$$S = f(T, M, C) \tag{2}$$

In formula (2), S : the macroscopic state vector of the teaching system; T : teaching; M : management; C : teaching conditions. Formula (2) indicates that the macro state of the teaching system is related to the above three factors and is a function of these three factors. Taking the total differential on both sides of formula (2), we have:

$$dS = (\frac{\partial f}{\partial T})_{M.C}\, dT + (\frac{\partial f}{\partial M})_{T.C}\, dM + (\frac{\partial f}{\partial C})_{T.M}\, dC \tag{3}$$

If there is no significant change in teaching conditions and management quality within a short period of time, it can be approximated that m and c remain constant during this period of time. This approximate condition is expressed as:

$$D_m = D_c = 0$$

Under this approximate condition, equation (3) can be simplified as:

$$dS = (\frac{\partial f}{\partial T})_{M.C}\, dT \tag{4}$$

Integrate equation (4), and make:

$$F_{M.C}(T) = \int \left(\frac{\partial f}{\partial T} \right)_{M.C} dT \tag{5}$$

Thus we get

$$F(T) = \Delta S = S_1 - S_0$$

Suppose the macro state vector of the teaching system is $S = f(x_1, x_2, \cdots, x_n)$, We have

$$F(T) = \Delta S = (x_1^1, x_2^1, \cdots x_n^1) - (x_1^0, x_2^0, \cdots, x_n^0)$$

Similarly, if in a short period of time, approximately consider that T , L lare unchanged, or T , M are unchanged, after similar processing, we can also get the functions are:

$$F(M) = \Delta S, F(C) = \Delta S$$

These are simplified teaching system equations, which may not necessarily be precise, but they enable us to obtain the possibility of teacher work quality or management quality from changes in the macroscopic state of students. We call this formula is the ΔS (incremental) equation of the teaching system. This paper uses this ΔS equation to discuss the evaluation of teachers' teaching quality.

3.2 Effect Evaluation Method Based on ΔS Equation

If the teaching process is regarded as a control system, Figure 1 shows the input and output of the teaching system.

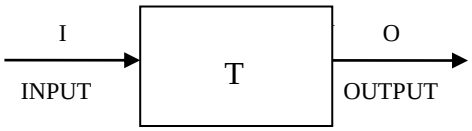

Figure 1. Schematic diagram of the input and output of the teaching system

In Figure 1, T represents the teaching system, I represents the input of the system, and O represents the output of the system. If a teaching system only knows its input value and output value, but its internal structure is unknown, we call it the "black box" of the teaching system. According to the control mechanism of the teaching system: "Only by observing the output reflection caused by the input change, the behavioral characteristics of the system can also be deduced." When the internal structure of the teaching system is uncertain, the function of the system can be analyzed according to the input and output of the system, identify the behavior of the system. In the expression of the ΔS equation, if we regard S_0 as the input value of the teaching system and S_1 as the output value of the teaching system, then the practical significance of using the d equation to evaluate the teaching quality is: according to the input and output data to analyze teaching system behavior.

4. APPLICATION OF ΔS EQUATIONS

According to the ΔS equation of the teaching system, the state vector S of the teaching system is described by the macroscopic description method. In practical applications, according to the content of the macroscopic state vector S, the effect analysis of teachers' teaching quality can be divided into XE analysis, Markov process analysis and comprehensive analysis.

4.1 ΔS Equation and the XE Analysis Method of Teaching Quality

The XE analysis method of teachers' teaching quality is to use the average X of the students' academic performance in each class and the degree of deviation E of the students in the class from the average as the indicators of the effect of teaching quality, that is,

$$\bar{X} = \frac{1}{n}\sum X_i \ , \ E = \frac{1}{n}\sum \left| X_i - \bar{X} \right|$$

Then, we examine X and E in two different periods, and make different evaluations of teaching work according to their changes. In fact, taking X and E as independent variables of the state vector, we have

$$\Delta S = (X_1 - E_1) - (X_0 - E_0)$$

Obtain X and E, and then evaluate the teaching quality according to the content of Table 1. The evaluation of teachers' teaching quality is divided into 9 grades: excellent, better, good, poorly, general, poorly, poor, very poor and worst.

Table 1. XE Evaluation form

ΔX	ΔE	Teaching quality
>0	>0	Excellent
>0	=0	Better
>0	<0	Good
=0	>0	poorly
=0	=0	general
=0	<0	poorly
<0	>0	poor
<0	=0	very poor
<0	<0	worst

4.2 ΔS Equation Combined with Markov Analysis

The XE analysis method of teachers' teaching quality has the advantages of being simple, clear and suitable for application, but it has its shortcomings. First, the final evaluation criteria are subjective. For example, there is no convincing proof why an increase in E must be better than a decrease in E. Secondly, this method of analysis loses a lot of information, and it is impossible to give more guidance to actual teaching activities. Therefore, some researchers have introduced the Markov process analysis method of teaching quality.

The Russian mathematician Markov once pointed out that there is a class of things in nature and society whose changes are related to their recent state (. The influence of the past state of things on their changes is all reflected in their recent state, that is, the state of things at time T depends on the state at time $T-1$, and its state at time $T+1$ depends on the state at time T. Moreover, Markov made a mathematical analysis of the process with this property. For this reason, a process with this property was later called a Markov process. This method of analyzing the Markov process using a dynamic stochastic mathematical model is called

Markov analysis. Markov process analysis of teacher teaching quality is a statistical analysis method. It takes a group (Lv, 2012). a class or a grade) the proportion of students who have obtained excellent, good, medium, passing and failing grades to the total number of students as a state variable, and represents it with a state vector $S(t)$ (Yuan, 2021).

$$S(t) = (X_1(t) \quad X_2(t) \quad X_3(t) \quad X_4(t) \quad X_5(t)$$

We use an example to verify the effect of combining the△S equation with Markov analysis.

4.3 Examples and Discussions

For example, after an exam, among the 50 students in a class, there are 9 outstanding students, 18 good students, 15 average students, 6 passing students, and 2 failed students, so the state vector is can be written as:

$$S(2) = (9/50, 18/50, 15/50, 6/50, 2/50) = (0.18, 0.36, 0.30, 0.12, 0.40)$$

We know that the △S equation of the teaching system is determined by the changes between two states at different times. If after the second test, 6 of the 9 students who originally got excellent grades will continue to be excellent, 2 will drop to good, and 1 will drop to medium. Therefore, we can get the transfer of the 9 students who got excellent grades in the first exam: $(6/9, 2/9, 1/9, 0, 0)$.

Because of the original 18 students who got good grades, in the second test, 3 students rose to excellent, 9 students remained good, 6 students fell to average, and 0 students were below average. The transfer of grades can be expressed as: $(3/18, 9/18, 6/18, 0, 0)$.

Using the same method, we can obtain the changes in the performance status of the remaining students: $(1/15, 3/15, 6/15, 4/15, 1/15)$, $(0, 1/6, 1/6, 3/6, 1/6)$, $(0, 0, 0, 1/2, 1/2)$. The matrix of the above changes is expressed as:

$$G = \begin{bmatrix} 6/9 & 2/9 & 2/9 & 0 & 0 \\ 3/18 & 9/18 & 6/18 & 0 & 0 \\ 1/15 & 3/15 & 6/15 & 4/15 & 1/15 \\ 0 & 1/6 & 1/6 & 3/6 & 1/6 \\ 0 & 0 & 0 & 1/2 & 1/2 \end{bmatrix}$$

And the following equation holds between $S(2)$ and $S(1)$:

$$S(2) = S(1) \cdot G$$

Obtained by matrix operation:

$$S(2) = (0.18, 0.36, 0.30, 0.12, 0.14) \begin{bmatrix} 6/9 & 2/9 & 2/9 & 0 & 0 \\ 3/18 & 9/18 & 6/18 & 0 & 0 \\ 1/15 & 3/15 & 6/15 & 4/15 & 1/15 \\ 0 & 1/6 & 1/6 & 3/6 & 1/6 \\ 0 & 0 & 0 & 1/2 & 1/2 \end{bmatrix}$$

$$= (0.20, 0.30, 0.28, 0.16, 0.06)$$

The general expression for this relationship is:

$$S(t+1) = S(t) \cdot G$$

The above relationship determines that the ΔS equation of the Markov process teaching system is a matrix equation:

$$\Delta S = S(t+1) - S(t) = S(t) \cdot G - S(t) \quad = [G - I]S(t)$$

In Equation 9, I is the identity matrix, that is:

$$\begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

In a Markov process, G is called the transition matrix. According to the nature of the Markov process, it is possible to infer what will happen next exam.

$$S(t+2) = S(t+1) \cdot G = S(t) \cdot G \cdot G = S(t) \cdot G^2$$

From a mathematical point of view, the transition matrix has an important property: if $S(0)$ is the initial vector, then there is K under the action of G, the state can reach an equilibrium state after K transitions, that is, the state no longer changes on the macroscopic level, We have

$$S(K) = S(K+1) = S \quad \text{（equilibrium）}$$

Of course, it should be pointed out that in the equilibrium state, the micro-changes among the personnel of each part of the system still exist, but the relative proportion of the personnel of each part no longer changes. This equilibrium state is generally referred to as the limit state. It is especially important that if G is not block-diagonal (here, it means that personnel at each level can move to any level), then the limit state of the teaching evaluation system has nothing to do with the initial state of the system, that is, it has no relationship with $S(0)$. It is only related to the transition matrix G, that is to say, the teaching quality evaluation is completely determined by G.

The above analysis shows that this property of the Markov process transition matrix is very meaningful in the evaluation of teaching quality. The change of students' academic performance reflects the teaching effect of teachers. Therefore, the transition matrix is a reflection of factors such as teaching quality and certain teaching conditions. The limit states of the Markov process show how far students are generally possible under these conditions if these factors are stable. This possible degree is independent of the student's learning base. Therefore, the limit distribution of Markov process can be used as an evaluation method of teaching quality, and the influence of students' basic differences can be solved when evaluating teaching quality by using students' grades.

5. CONCLUSION

Study shows that the digital teaching quality management is the key to establish a mathematical model of the teacher's teaching, that is to say, only the formal teaching activities, teaching quality data analysis can be realized, thus established on the basis of algorithm and data analysis of teachers' teaching evaluation in order to achieve the objective, the rationalization and scientific requirements. By combining △S equation with the two methods, the results show that the Markov teaching process evaluation method based on △S is ideal and can be applied to the real teaching quality evaluation of teachers.

ACKNOWLEDGEMENT

At the time of publication of this paper, I would like to express my heartfelt thanks to Professor He Ping for his kind guidance. I also want to thank my family for their support and help.

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