

Application Research of Fuzzy Theory in PE Teaching Evaluation

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Abstract

Comprehensive evaluation of PE teaching is always one of the difficulties of teaching management for universities; This paper, on the basis of analyzing the fuzzy features of teaching evaluation, puts forward fuzzy evaluation model of PE teaching. The model first discards the defects of traditional evaluation methods which always neglect the specific characteristics of PE teaching, instead, takes teaching objectives and results as orientation, designs new comprehensive evaluation indicators for PE teaching; Second, analytic hierarchy process and multivariate fuzzy evaluation method are used to build the evaluation model for PE teaching through building membership function and comprehensive evaluation matrix of fuzzy comprehensive evaluation; Finally, the model is realized by the data from three universities to carry out comprehensive evaluation on PE course and the experimental results indicate that the presented model has satisfied application results in evaluation accuracy and time consumption compared with traditional methods.

Keywords: fuzzy theory, analytic hierarchy process, PE teaching evaluation, multivariate evaluation

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1. Introduction

Teaching effect evaluation is one of the main contents of PE teaching management; teaching effect of courses has also become one of the main contents to evaluate a teacher. There are lots of methods for institutions of higher learning to evaluate teachers' teaching effect, which mainly include experts' evaluation, leaders' evaluation, peer teachers' evaluation and students' evaluation. As PE course teaching not only is a multilevel and high-dimensional dynamic process, but also involves a lot of particularity and random factors, correct evaluation on PE teachers appears to be more complicated [1, 2]. As to current evaluation on PE teaching dominated by leaders, experts, peers and students, as well as comprehensive evaluation indicator system, although our country plays a certain facilitating role in the evaluation study and practice on PE teaching, such kind of method neglects the particularity of PE teaching in essence, adopting the same standard and indicator system as the other subjects as for specific evaluation; also, the evaluation generally focuses on the teaching effect of specific knowledge and skill, while ignores the education of students' attitude and emotion on PE and social adaptability. Therefore, the conventional evaluation method is inevitably biased on the evaluation result of PE teaching, unable to truly reflect the classroom teaching effect of PE teachers [3, 4].

In light of subjectivity, fuzziness, dynamics and intermediate transitivity of evaluation indicator of PE teaching performance, it cannot be described and verified accurately and rigidly; this paper, through study on fuzzy membership functions of evaluation indicators, combines analytic hierarchy process with fuzzy hierarchy evaluation method to carry out comprehensive evaluation, so as to conquer the problems that quantitative method neglects the characteristic of real-time dynamics of influencing factors while qualitative method is relatively subjective, also conquer the problems that analytical hierarchy process has large error while evaluating multi-indicator system and rigidness determination of membership function in fuzzy evaluation method, and give play to the technical expertise of two evaluation methods.

2. Evaluation Indicators Design

2.1. Analysis of Factors Influencing Course Teaching Effect

At present, our country is widely promoting course teaching evaluation; course evaluation indicators are also gradually improving and perfecting; here, taking student side as example, analyze the factor indicators influencing course evaluation. Such aspects as students' capability and quality as well as initiative in learning, students' preference to different courses, and study atmosphere in school play an important role in the evaluation on classroom teaching. Besides, the characteristics, difficulty of learning and interestingness of the course also exert an impact on evaluation results; although such factors are not within the scope of teaching quality, they shall be taken into consideration in the case of specific evaluation. Moreover, evaluators (such as some students) don't pay enough attention to the teaching evaluation, even just coping with problems. From the perspective of technology, whether evaluators (such as some students) are able to correctly understand and master evaluation standard shall be paid high attention. So, evaluation indicators influencing classroom teaching effects are complicated and varied [5, 6].

2.2. Main Evaluation Indicators Taken as Reference

Such four aspects as teaching contents, teaching effect, teaching method and teaching attitude are prevailing evaluation indicators of classroom teaching in China, which play a facilitating role in the improvement of teaching quality, as well as a supervising and assessing role as for teachers, also urging teachers to actively enhance teaching method and provide best teaching quality within their power. However, such indicators have some obvious defects, for example, some evaluation indicators are lack of specific course features and evaluation flexibility; some of them are not clear enough in definition, lacking good operability and reliability in specific practice; different understanding of different teachers on teaching evaluation also directly influences evaluation indicators. If students fail to correctly respond to evaluation result of teaching effect and teachers' teaching quality, some teachers may misunderstand teaching evaluation, thus affecting the teaching quality and teaching effect of the teacher. Besides, these teaching evaluation indicators system may consider as subjective confirmation of indicator standard and each indicator weight in specific operation; evaluation indicators of some institutions fail to keep pace with the era, still remaining in the level of years ago, unable to reflect new teaching concept and evaluation method, all of which seriously restrict the promotion of classroom teaching reform. As for these problems, at present, many school administrators and teachers study accurate and reasonable evaluation indicator system of classroom teaching, so as to correctly, fairly and roundly carry out evaluation on teachers' classroom teaching effect, for the sake of giving better play to classroom teaching evaluation, thus improving teachers' initiatives in teaching reform and in enhancing teaching effect [7, 8].

Indicator system of teaching evaluation in the USA not only is rich and specific but also has high discrimination, with strong feasibility in specific operation. For instance, in China, grades for teachers' teaching evaluation are generally excellent, good, medium and poor. While those in the USA are more specific, taking the evaluation report of teachers' teaching effect of ETS (Educational Testing Service) as example, students divide teaching effect evaluation grades into such 5 grades as Outstanding (the best, top 10%), Excellent (good, top 30%), Good (general), Poor (worse than the most people, bottom 30%), Fail (the worst, bottom 10%); such kind of evaluation grades accurately define the range of evaluation subjects and objects. Taking the evaluation indicators of teachers' course teaching put forward by University of Illinois in the USA as another example, the indicators mainly include: whether asking a rhetorical question shall be adopted to inspire students' learning interest and guide students' thinking in learning. The indicator system also pays a special attention to students' confusion, antipathy, interest and other responses to the course contents, so that the indicator is accurate in content in specific operation, which will not make evaluation subjects and objects have any misunderstanding. Meanwhile, the method for teachers' teaching evaluation of the USA is simple and feasible. The prevailing evaluation method in American institutions is student classroom evaluation; about 70% of the institutions have formed favorable systematical teaching evaluation method; in the evaluation, students are the subjects; all they need to do is to spend one minute to evaluate a teacher without indicating their names. Teaching administrative departments can also supervise and evaluate teachers' teaching effect anytime, as well as tell teachers students' specific feeling and improvement suggestions on classroom teaching.

2.3. Establishment of Evaluation Indicators of PE Course Teaching

Taking successful experience in evaluation system of classroom teaching at home and abroad as reference, also in consideration of the special nature of PE course teaching, it overcomes the shortcoming that traditional course evaluation starts from four dimensions as teaching contents, teaching attitude, teaching method and teaching effect, thus lacking of features of PE course evaluation. Thispaper, while designing specific evaluation indicators system, carries out evaluation on learners' learning outcome based on learners' behavior changes before and after PE learning. Evaluation dimension stretches from such five aspects as students' sports skill, verbal skill, teaching attitude, discernment and cognitive skill; evaluation contents mainly include completion quality of sports actions, ability to state action specification, ability to understand PE principles and concepts, ability to use PE knowledge and skill and ability to analyze problems in PE; behavioral expression is mainly to investigate the changes of students' behavior after PE teaching; action verbs correspond to behavioral expressions, mainly helping evaluators list verbs of ability mastering. PE teaching evaluation system established in thispaper is shown as below [4-6].

Table 1. PE Teaching Evaluation System Constructed in This Paper

Evaluation Dimension	Evaluation Content	Behavioral Expression	Behavioral Verb	Specific Case
Action Skill	Action Behavior Action Quality	Able to complete the action or not	Able to complete	Demonstration teaching of action like standing broad jump
	Individual Difference	Quality of action completion (speed, strength, accuracy, etc.)	Able to implement	
Verbal Skill	Action Name Action Essentials	Able to correctly state contents needing evaluation or not	Able to state or not (in written or oral form)	State the action essentials of standing broad jump
	Action Requirement Protection Help			
Teaching Attitude	Choosing of PE teachers and specific items	Positive teaching attitude or not, like it or not, accept it or not	Choose (yes or no)	Active and earnest in class, not late for class
Discernment	Able to respond to different stimulation (actions, words) or not	Different responses to different actions	Distinguish (indicate different actions)	Distinguish standing broad jump from triple jump
Cognitive Strategy	Guide and govern teachers' cognitive behavior with concepts	Able to adopt various internal mechanisms to solve practical problems or not	Adopt	Application of previous teaching experience
Specific Concept	Ability to distinguish specific actions (concepts, actions, gestures)	Able to distinguish the features or attributes of actions or not	Distinguish	Find out standing broad jump action in lots of actions
Defining Concepts	Understanding and classification of relationship among concepts	Able to analyze certain concept with definition	Classify certain action	Classify actions related to broad jump according to the concept of broad jump action
Rule	Able to understand the concept of action and carry out demonstration	Able to illustrate or not	Demonstrate actions	Accurately understand what is standing broad jump and carry out word picture or operation demonstration

3. Research Method

3.1. Rationality Analysis of Fuzzy Evaluation

While evaluating course teaching effect, there are lots of problems difficult to be simply described with points; for example, while evaluating a teacher of certain course, factors influencing evaluation result are mainly educational background of the teacher, humanistic feeling, teaching concept, and etc. Therefore, different people (including students, peers and experts) may have different evaluations, the evaluation results of whom are also difficult to be

quantized. So the evaluation results shall express specific concepts with fuzzy language. Besides, in practical application, the discussed objects are affected by a lot of uncertainty factors, among which fuzziness factor is one of the main influencing factors. Such kind of combination of classical comprehensive evaluation theory with fuzzy theory appears to be logical to evaluate courses. For this reason, the fuzzy comprehensive evaluation method adopted in this paper has good rationality, scientificity and operability, able to obtain relatively correct, fair and reasonable evaluation results [9, 10].

The most frequently used in fuzzy decision is fuzzy comprehensive evaluation method, which tries to deduce comprehensive evaluation model of fuzzy mathematics based on fuzzy evaluation theory, and carries out roundly comprehensive evaluation on teachers' course teaching with this, also very effective in specific utilization. To correctly and reasonably stipulate the domain of discourse of fuzzy evaluation and establish fuzzy evaluation matrix is the key to successfully apply fuzzy comprehensive evaluation model [9].

3.2. Determining Membership Function

The basic thought of fuzzy theory is the thought of the membership degree attribute towards subject; as previously mentioned, the key to apply fuzzy evaluation model lies in establishing reasonable fuzzy evaluation model, while the key to build fuzzy comprehensive evaluation model is to reasonably build membership function conforming to the facts. The method of determining the membership function of certain fuzzy set remains a difficulty needing to be solved up till now. According to the specific features of comprehensive evaluation of PE course teaching effect, this paper adopts fuzzy statistical method to determine the membership function of fuzzy evaluation model [11].

Determining membership function of attribute towards object with fuzzy statistical method is a relatively objective method, which is also widely used. This method, in the specific operation, through fuzzy statistical test, according to the actual existence of membership of attribute, determines specific membership. Fuzzy statistical test generally includes four factors which are domain of discourse U , fixed element x_0 in U , a common set A^* formed by random variables in U , a fuzzy set A in U (taking A^* as elastic boundary, and restricting the change of A^*). Among the above four elements, $x_0 \in A^*$, thus, the membership function of x_0 towards A is unable to be fixed and determined [12].

Now suppose that experimenter does n times of fuzzy statistical test, he/she can carry out calculation according to Formula 1 to calculate membership frequency of x_0 as follows.

$$A = \frac{\text{Times of } x_0 \in A}{n} \quad (1)$$

In specific calculation, with the increase of test times n , membership frequency is gradually stable; the stable frequency value is called membership of x_0 towards A in fuzzy mathematics, i.e. Formula (2) [13].

$$\mu_A(x_0) = \lim_{n \rightarrow \infty} \frac{\text{Times of } x_0 \in A}{n} \quad (2)$$

3.3. Establishment of Fuzzy Comprehensive Evaluation Matrix

The second key to successfully use fuzzy comprehensive evaluation model is to reasonably build fuzzy comprehensive evaluation matrix. Now use $U = \{u_1, u_2, u_3 \dots u_n\}$ to express n kinds of indicators (or influencing factors) of study object, which can be called indicator set (or factor set). Use $V = \{v_1, v_2, v_3 \dots v_m\}$ to express evaluation set (also called evaluation set, decision set, etc.), formed by m kinds of evaluation indicators of all the indicators (i.e. factors). Indicators (number and name of indicators) can be generally determined according to decider's specific demand in specific evaluation. As previous said, in the practical

practice of evaluation, the evaluation set of indicators (factors) of many problems is not that clear, instead, it is relatively fuzzy. So comprehensive evaluation result is a fuzzy subset on V , as shown in Formula (3) [14].

$$B = (b_1, b_2, b_3, \dots, b_k) \in F(V) \quad (3)$$

In Formula (3), membership of evaluation b_k towards fuzzy subset B is obtained through the calculation of $\mu_B(v_k) = b_k (k = 1, 2, 3, \dots, m)$, which can reflect the role of the k th evaluation v_k played in comprehensive evaluation. Comprehensive evaluation set B relies on the weight values of each indicator, i.e. B shall be the fuzzy subset on indicator set U , $A = (a_1, a_2, a_3, \dots, a_n) \in F(U)$, and meeting that the sum of indicator weight is 1; in which a_i indicates the weight of the i th indicator. Hence, while the weight set A is set, a corresponding comprehensive evaluation set B can be determined. General steps to determine fuzzy comprehensive evaluation mainly include the following ones.

- 1) Determine indicator set $U = \{u_1, u_2, u_3, \dots, u_n\}$;
- 2) Calculate determination evaluation set $V = \{v_1, v_2, v_3, \dots, v_m\}$;
- 3) Calculate determination fuzzy evaluation matrix $R = (r_{ij})_{n \times m}$;

While determining fuzzy evaluation matrix $R = (r_{ij})_{n \times m}$, first, carry out evaluation of $f(u_i) = (i = 1, 2, 3, \dots, n)$ on each indicator u_i , a fuzzy mapping f from indicator set U to evaluation set V can be obtained; the mapping is as shown in Formula (4).

$$\begin{aligned} f: U &\rightarrow F(U) \\ u_i &\mapsto f(u_i) = (r_{i1}, r_{i2}, r_{i3}, \dots, r_{im}) \in F(V) \end{aligned} \quad (4)$$

Then, deduce fuzzy relation $R_f \in F(U \times V)$ according fuzzy mapping f , as shown in Formula 5.

$$R_f(u_i, v_j) \in f(u_i)(v_j) = r_{ij} = (i = 1, 2, 3, \dots, n; j = 1, 2, 3, \dots, m) \quad (5)$$

As a result, fuzzy evaluation matrix $R = (r_{ij})_{n \times m}$ can be calculated, (U, V, R) is the model of fuzzy comprehensive evaluation; U, V, R are generally called the necessary elements of the model.

- 4) Comprehensive evaluation: as to a set in which weight $A = (a_1, a_2, a_3, \dots, a_n) \in F(U)$, through model $M(\vee, \wedge)$, take compositional operation of maximum—minimum, then obtain final comprehensive evaluation matrix, as shown in Formula 6.

$$B = A \circ R (\Leftrightarrow b_j = \bigvee_{i=1}^n (a_i \wedge r_{ij}), j = 1, 2, 3, \dots, m) \quad (6)$$

According to the above, we can know that the correct determination of weight $A = (a_1, a_2, a_3, \dots, a_n)$ in evaluation set V plays a critical role in final comprehensive evaluation. $A = (a_1, a_2, a_3, \dots, a_n)$ is generally determined by model designer by virtue of self relevant experience, but this is often subjective. If the weight set is to reflect actual situation, to objectively and faithfully reflect actual situation, weighting statistics, experts evaluation or fuzzy

relation can be adopted to determine $A = (a_1, a_2, a_3 \dots a_n)$; for practical application, different determination methods can be chosen according to different situations [5].

3.4. Specific Application of Fuzzy Comprehensive Evaluation of PE Course Teaching

In the specific application of fuzzy comprehensive evaluation in this paper, carry out hierarchical division on all the evaluation indicators of PE course teaching, making use of analytic hierarchy process to calculate indicator weight coefficients at different levels; each weight is calculated from bottom hierarchy to high hierarchy, i.e. calculating hierarchy-by-hierarchy to obtain final evaluation score; meanwhile, in order to guarantee the scientificity of evaluation, each evaluation indicator is divided into three hierarchies such as students' evaluation, peer teachers' evaluation and experts' evaluation, synthesizing the evaluations at all hierarchies to obtain diversified teaching evaluation result [5].

In the multivariate teaching evaluation model of this paper, after obtaining weight coefficients of relevant indicators through analytic hierarchy process, fuzzy comprehensive evaluation shall be adopted on the evaluation calculation process of teachers' teaching job (here taking students' evaluation as example) to obtain specific evaluation score of teachers' courses. Specific methods are listed as follows: first, determine each indicator of fuzzy comprehensive evaluation, such as action skill teaching set $U = (\text{action behavior, action quality, individual difference})$, evaluation set $V = (\text{excellent, good, medium, poor})$, weight set of students' evaluation of teachers' course teaching effect $W = (W_{A1}, W_{A2}, W_{A3} \dots W_{An})^T$; at the same time, define weight set value as $W = (0.1, 0.159, 0.256, 0.419, 0.066)^T$, lastly, obtain final fuzzy evaluation matrix R through membership function set.

Here taking students' evaluation as example to illustrate the determination method of membership function set. First, select 30 students with responsibility from the class to evaluate teachers' teaching effect, and students check "√" at different indicators and different effect grades in the evaluation form. Then, make statistics and processing on the valid information in the effect evaluation form. Method adopted in evaluation information statistics is: make statistics on persons of different effect grades in B_1 indicator evaluation set, for instance, 8 persons check "excellent" option, 17 persons check "good" option, 4 persons check "medium" option and 1 person checks "poor" option, through calculation, B_1 indicator membership function set is obtained as $R_i = (0.27, 0.57, 0.13, 0.03)$; through the above method, the membership function set R_i of all the indicators can be obtained; then fuzzy evaluation matrix R is formed by R_i ; final teachers' teaching evaluation set can be obtained through Formula 7.

$$B = W * R = [w_1, w_2, \dots, w_n] * \begin{bmatrix} r_{11}, r_{12}, \dots, r_{1n} \\ r_{21}, r_{22}, \dots, r_{2n} \\ \dots \dots \dots \\ r_{m1}, r_{m2}, \dots, r_{mn} \end{bmatrix} = [B_1, B_2, \dots, B_n] \quad (7)$$

Carry out normalization process on comprehensive evaluation set matrix B with Formula 7; then in accordance with maximum membership principle, comments of course teaching evaluation shall be recorded with corresponding comments (maximum) in normalized B . Formula 8 and Formula 9 can obtain specific score. The entire process seems to be a little bit complicated, but the process can be completed by computer. Hence, it's not that difficult.

$$\text{Students' score} = B_1 * \text{Excellent}_1 + B_2 * \text{Good}_2 + B_3 * \text{Medium}_3 + B_4 * \text{Poor}_4 \quad (8)$$

$$\text{Score} = (\text{Excellent}_1, \text{Good}_2, \text{Medium}_3, \text{Poor}_4) = (95, 85, 75, 60) \quad (9)$$

The above is the score taking students as evaluation subjects; evaluation quantitative process of other evaluation subjects (peer teachers and experts) is similar to this, and the total evaluation score of other evaluation subjects can be calculated respectively. Finally, according to the weight (0.4, 0.3, 0.3) distributed to students, peers and experts, the weight value is set by deciders with their experience, which can be adjusted as the case maybe. In the end, calculate final evaluation score of PE course teaching through Formula 10.

$$ComprehensiveScore = [W_{Student}, W_{peers}, W_{Experts}] * \begin{bmatrix} StudentScoring \\ PeerScoring \\ ExpertScoring \end{bmatrix} \quad (10)$$

4. Results and Analysis

4.1. Data Acquisition and Pre-processing

Experimental data come from database of distance training schools of Shanghai University of Sports, and Shanghai Jiaotong University and South China University of Technology. Relevant data of 3000 learner of each university are selected as the basis for data training and experimental verification in the paper, totally 9000 learns' data for study data that come from practical investigation and visit of two specific PE students. In order to make the selected learners' data representatives, 1500 learners (500 learner from each university) with more than 3 years learning experience, 6000 learners with 2 years learning experience, 1500learners with less than 2 years learning experience.

The questionnaires of the evaluation indicators for PE course teaching were made and surveyed to the teachers and students to get the score of each indicator for different universities.

The original data acqired by the survey are pre-processing to the scope of the fuzzy matrix and the final scope of the score is [0,5].

4.2. Experimental Results and Analysis

Limited to paper space, the evaluation of intermediate results is omitted here, only providing secondary evaluation results and final comprehensive evaluation results, see Table 2 and Table 3.

Table 2. Secondary Evaluation Results of Different Universities

	Action Skill	Verbal Skill	Teaching Attitude	Discernment	Cognitive Strategy
Shanghai University of Sports	4.451	3.871	4.542	4.761	4.761
Shanghai Jiaotong University	3.672	3.532	3.791	4.651	4.461
South China University of Technology	3.573	3.332	3.345	4.875	4.381

Table 3. Final Evaluation Results of Different Universities

	Shanghai University of Sports	Shanghai Jiaotong University	South China University of Technology
Final evaluation	4.562	3.871	3.345

In order to illustrate the value of the presented algorithm and some other algorithms which are popular used for teaching evaluation are realized with the same calculation platform in the paper. The indicators of the calculation platform can be listed as follows Intel i3 2120, 2GB DDR3, AMD Radeon HD 7450 and 3.3GHz CPU, and windows XP. The Table 4 can shows that the evaluation accuracy and time consuming of the differents algorithms. Form the table we can see clearly that the algorithm in the paper has greater value than that's of BP neural network [14] and fuzzy evaluation algorithms in evaluation accuracy or time consuming. In realization practice, the paper take some obvious indicators as sample to calculate evaluation accuracy in order to make our campaisn more beliveable.

Table 4. Realization Results of Different Algorithms

	Algorithm in the paper	Ordinary Fuzzy model	BP Neural Network
Evaluation Accuracy	95%	73%	91%
Time Consuming (S)	14	13	889

5. Conclusion

Due to the specific features of PE course teaching, as to each course evaluation qualitative indicator described with fuzzy language, the disadvantage of traditional evaluation method which is subjective and optional can be better avoided, and with the unique evaluation indicators designed for the specific features of PE course teaching, fuzzy evaluation can be effectively implemented for PE course, which also possesses good rationality and scientificity. But fuzzy evaluation also has the problems when determining the weight distribution of each evaluation indicator. The paper uses analytic hierarchy process to solve above problems and represents a new evaluation algorithm which can improve the evaluation accuracy greatly and time consumption is also can be accepted in practice compared with ordinary fuzzy evaluation.

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