An Innovative Study on Establishing an Evaluation System for College PE Teachers' Professional Capacities

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***Abstract* — To establish a scientific and fair evaluation system, 3 first-level indices (ability, quality, and knowledge of the PE teachers) and 18 second-level indices were setup by conducting a literature review and a survey. The weights of the indices were determined using the analytic hierarchy process. Also, a fuzzy comprehensive evaluation was conducted on teachers with the students, in the presence of other teachers and administrative staff as the evaluators. This results in the development of a more scientific evaluation system for college PE teachers' professional capacities and a practical mathematical model.**

Keywords — PE teachers; Ability; Quality; Knowledge; Evaluation system

I. INTRODUCTION

Establishing an evaluation system for college PE teachers is an effective way to make comprehensive assessment of them, which not only increases the teaching level, but also standardizes their professional quality, skill, and knowledge, thus to provide a reference for PE teachers' teaching results.

In this study, National Board for Professional Teaching Standards[1] was used for reference with colleges PE teachers in Guangzhou as research subject, and the students' learning outcomes and comments on PE teachers were taken into consideration, aiming for a more comprehensive, scientific, reasonable, and innovative evaluation system[2].

A. Definitions

The definitions of "ability", "quality", and "knowledge" in this study were as follows:

Ability: the required abilities of PE teacher in order to meet the working target of PE subject in school and to utilize the known knowledge effectively, such like the ability of thinking and special ability in sport field.

Quality: namely professionalism, the requirement of PE teachers' personal qualities in the aspect of teaching.

Knowledge: the theories and skills that PE teachers were required to master to finish their job smoothly and quickly, as well as the information, facts, and opinions that can be mastered through learning.

II. RESEARCH SUBJECT AND METHOD

The study aimed at the college PE teachers' comprehensive capacity. Based on the massive literature review on college PE teachers' quality, ability, and evaluation, the evaluations of their ability, quality, and knowledge were determined as the research object. Questionnaires on evaluation of teachers' professional capacities were given out to students, teachers, and administrative personnel in typical "211 project" universities

(Sun Yat-sen University, South China University of Technology, Jinan University, and South China Normal University). The weights of the indexes were calculated based on the survey of their importance by PE specialists in colleges in Guangzhou. Lastly, fuzzy comprehensive evaluation method[3] was applied in assessing the professional capacities of college PE teachers in Guangzhou with the reference of related theories, and a comprehensive evaluation system was developed, as well as the conclusions and suggestions.

III. RESULTS

A. Establishing the professional capacities evaluation system for college PE teachers in Guangzhou.

The evaluation system consists of indexes, the weight of indexes, and evaluation criterion. The establishment of the indexes is based on literature review and related theories with the adjustment of practical PE teaching situation in Guangzhou. It includes several elements, which could be broken down into many detailed indexes.

B. Deciding the Indexes for the Evaluation System

Primary indexes were selected on the basis of a full review of findings by other scholars and researchers, especially the indexes on the evaluation of college PE teachers, and then a second-round selection was conducted by relevant specialists after a full analysis. Eighteen second-level indexes were determined in Table 1 as below:

TABLE 1: FIRST-LEVEL AND SECOND-LEVEL INDEXES FOR THE EVALUATION SYSTEM OF COLLEGE PE TEACHERS IN GUANGZHOU

First-level	Second-level
Ability	Teaching ability, innovation ability, thinking ability, specific performance ability, language skills, and management and organizational skills
Quality	Professional ethics, professional attainments, dedication and sense of responsibility, knowledge of literacy, group spirit, and social competence
Knowledge	Knowledge of physical education theories, special skill, modern education, social science, humane studies, and health care in sports

C. Deciding the weights of the indexes.

To assure the validity of the evaluation result, Delphi method and Analytic Hierarchy Process were employed to determine the weights of the indexes. Its calculation method was the same as that of the specialists.

1) Basic steps of Analytic Hierarchy Process

①Establishing the hierarchy. The elements in each level of the index system contained several sub-level elements, making a hierarchy.[4]

②Establishing a series of judgments based on pair-wise comparisons of the elements. For the elements in each subdomain included an element and its next-level elements, Delphi method was adopted to establish a series of judgment matrices. [5]

If the first-level elements were set as standard and were related to the next-level elements, C_1, C_2, and C_n, the judgment matrix (Λ) was shown in Table 2 as below:

TABLE 2 JUDGMENT MATRIX

Λ_k	C_1	C_2	. . .	C_n
C_1	C_{11}	C_{12}	. . .	C_{1n}
C_2	C_{21}	C_{22}	. . .	C_{2n}
Λ	Λ	Λ	. . .	Λ
C_n	C_{n1}	C_{n2}	. . .	C_{nn}

where C_{ij} was relative to Λ_k, meaning the next-level elements' priorities to C_{ij}. The judgments of the priorities were quantified through a 1 to 9 scale, which were determined by the specialists according to their comprehensive judgments.

TABLE 3 DEFINITION OF THE WEIGHT OF THE INDEXES

Index	Definition and Description
1	Both elements have the same priorities on a certain property.
3	Compared with the other, the element is slightly more important.
5	Compared with the other, the element is obviously more important.
7	Compared with the other, the element is much more important.
9	Compared with the other, the element is extremely more important.
2,4,6,8	Represents the index that needs to strike an average between the above-mentioned criteria.
$1/C_{ij}$	The inverse comparing between two elements

The judgment matrix Λ had the following characteristics:

$$C_{ii} = 1;\ C_{ji} = 1/C_{ij};\ C_{ij} = C_{ik}/C_{jk};\ (i,j,k=1,2,\ldots.n)$$

③ Calculating in single level order.

Firstly, calculating the n-th root of product of all indexes in a whole line in the judgment matrix per Λ. $\underline{Wi} = \Sigma_1^n \underline{b_{ij}}$ (i =1, 2,….n).

Secondly, processing the vector W= (W_1 , W_2 , Λ, W_n) with a normalization method. $W_i = \underline{W_i}/\Sigma_1^n \underline{W_j}$. Gained the feature vector W=(W_1 , W_2 , Λ, Wn)^r, and its numerical value represented the weight.

Thirdly, calculating the max characteristic root λmYx in the judgment matrix, $\lambda mYx = \Sigma_1^n (BW)_i/nW_i$, where Y was the judgment matrix, and W was the corresponding feature vector.

④ Checking the consistency.

Firstly, calculating consistency index CI: CI=(λmYx – n)/(n-1).

Secondly, finding out the corresponding average random consistency index (n) based on the order (n) of the judgment matrix.

Thirdly, calculating the consistency ratio to confirm that the judgment matrix has satisfactory consistency.

⑤The comparison matrix between elements in the sub-level and its next-level based on AHP approach were constructed, and step ③ and step ④ were repeated until all levels were finished.

⑥Sorting the hierarchy and calculating the combined weight of the indexes in each level. Calculating the weight order of relative priorities to the target level of all elements in the index level, i.e. to multiply the weight of the elements in the last level by the corresponding weight of controlled elements in the prior level, thus to form the absolute weight of each element to the general target.

2) Calculating the weights of the indexes

The survey was conducted as follows:

TABLE 4 STATISTICS ON THE SURVEY

	Questionnaires	Responses (in %)	Effective responses (in %)
College students	200	177 (89%)	128 (64%)
PE teachers	30	24 (80%)	21 (70%)
Administrative personnel	20	17 (85%)	16 (80%)
Specialists	4	4 (100%)	4 (100%)

According to the evaluators' responses, an assessment model was developed through Delphi method and Analytic Hierarchy Process. The answers on the questionnaires were converted into 1 to 9, and the priorities were compared in pairs from top to bottom. The result was calculated by comparing the matrices of first-level indexes and second-level indexes. Finally, the weights of the indexes are as follows: students—0.519, PE teachers—0.284, and administrative personnel—0.197.

D. Establishing the evaluation criteria system for college PE teachers' professional capacities.

Objectivity: the people who are evaluated agree on the criteria;

Attainability: it can be achieved through efforts;

Transparency: the establishment of the criteria can be understood by any one;

Measurability: the results can be quantified by the establishment of the criteria.

E. Fuzzy Comprehensive Evaluation of College PE Teachers' Professional Capacities.

According to the foregoing index system, weight system, and criteria system for professional capacities evaluation of college PE teachers in Guangzhou, fuzzy comprehensive evaluation was conducted, provided a college PE teacher in Guangzhou needed a professional capacities evaluation.

1) Formation of a set of factors

The set of factors was formed in accordance with the two-level indexes. The sub-set of the evaluation system were (S, T, M), namely students, teachers, and administrative personnel.

Y_i= { Y_1, Y_2, Y_3 ,Y_4 ,… , Y_N } , where i= (1,2,3,4,…n) ; Y_i means first-level index, and Y_i= { Ability, Quality, Knowledge } (1)

Z_p= { Zp_1 ,Zp_2 ,Zp_3 ,…,Zp_m } , where p= (1,2,3,4,…m) ; Z_p means second-level index, and Z_1= { Z_{11} ,Z_{12} ,Z_{13} ,Z_{14} ,Z_{15} ,Z_{16} } = { Professional ethics, professional attainments, dedication and sense of responsibility, knowledge of literacy, group spirit, and social competence } (2)

Z_2= { Z_{21} ,Z_{22} ,Z_{23} ,Z_{24} ,Z_{25} ,Z_{26} } = { Teaching ability, innovation ability, thinking ability, specific performance ability, language skills, and management and organizational skill } (3)

Z_3= { Z_{31} ,Z_{32} ,Z_{33} ,Z_{34} ,Z_{35} ,Z_{36} } = { Knowledge of physical education theories, special skill, modern education, social science, humane studies, and health care in sports } (4)

2) Data collection

The establishment of the evaluation system is also based on an appropriate operation method so as to obtain a quantified result. For ease of calculating, all the data were simulated, given that a PE teacher's professional capacities was evaluated by 50 college students in Guangzhou, 10 PE teachers, 10 PE administrators and only one option in each second-level index could be chosen.

3) Calculation and comprehensive assessment by building fuzzy matrix

Step 1: assessing the feedback by the students, teachers, and administrative personnel

Single-factor assessment. Supposing SL_1 was the single-factor matrix from the degree of membership by the students' response:

$$SL_1 = \begin{pmatrix} 0.50 & 0.08 & 0.02 & 0.00 & 0.00 \\ 0.06 & 0.08 & 0.06 & 0.00 & 0.00 \\ 0.08 & 0.08 & 0.02 & 0.00 & 0.02 \\ 0.06 & 0.06 & 0.04 & 0.02 & 0.02 \\ 0.08 & 0.10 & 0.00 & 0.02 & 0.00 \\ 0.06 & 0.14 & 0.00 & 0.00 & 0.00 \end{pmatrix} \quad (5)$$

The corresponding weight matrix was SY_1=(0.300 0.213 0.100 0.085 0.260 0.042).

Therefore, the above data could be calculated as SC_1.

$$SC_1 = SY_1 * SL_1 = (0.51 \ \ 0.27 \ \ 0.15 \ \ 0.08 \ \ 0.03) \quad (6)$$

Same procedures were easily employed as follows:

$$SC_2 = SY_2 * SL_2 = (0.38 \ \ 0.33 \ \ 0.14 \ \ 0.09 \ \ 0.08) \quad (7)$$

$$SC_3 = SY_3 * SL_3 = (0.32 \ \ 0.39 \ \ 0.19 \ \ 0.04 \ \ 0.07) \quad (8)$$

Then, the first-level and second-level data was calculated. Take students' data for example.

Supposing the matrix of the first-level index was SR, which consisted of SC_1 (quality), SC_2 (ability) , and SC_3 (knowledge), then

$$SR = \begin{pmatrix} SC_1 \\ SC_2 \\ SC_3 \end{pmatrix} = \begin{pmatrix} 0.51 & 0.27 & 0.15 & 0.08 & 0.03 \\ 0.38 & 0.33 & 0.14 & 0.09 & 0.08 \\ 0.32 & 0.39 & 0.19 & 0.04 & 0.07 \end{pmatrix} \quad (9)$$

The general weight matrix of the first-level indexes was SY= (0.533 0.316 0.151) .

Supposing the evaluation result was SC_X, then:

$$SC_X = SY * SR = (0.533\ 0.316\ 0.151) * \begin{pmatrix} 0.51 & 0.27 & 0.15 & 0.08 & 0.03 \\ 0.38 & 0.33 & 0.14 & 0.09 & 0.08 \\ 0.32 & 0.39 & 0.19 & 0.04 & 0.07 \end{pmatrix} = (0.44\ 0.31\ 0.15\ 0.08\ 0.05) \quad (10)$$

Same procedures were applied to the teachers' and administrative personnel's evaluation result:

$$TC_X = (0.37\ 0.33\ 0.19\ 0.08\ 0.03) \quad (11)$$

$$MC_X = (0.85\ 0.77\ 0.18\ 0.02\ 0.02) \quad (12)$$

Step 2: assessing all of the evaluation results comprehensively

Supposing the comprehensive assessment of the matrix was R_T,which consisted of SC_X,TC_X, and MC_X.

$$R_T = \begin{pmatrix} SC_X \\ TC_X \\ MC_X \end{pmatrix} = \begin{pmatrix} 0.44 & 0.31 & 0.15 & 0.08 & 0.05 \\ 0.37 & 0.33 & 0.19 & 0.08 & 0.03 \\ 0.85 & 0.77 & 0.18 & 0.02 & 0.02 \end{pmatrix} \quad (13)$$

The weight coefficient of the degree of membership by the specialists could be obtain in the "comparison matrix", which is $M_S = (0.519\ 0.284\ 0.197)$

Supposing the final evaluation result was W, then

$$W = M_S * R_S = (0.519\ 0.284\ 0.197) * \begin{pmatrix} 0.44 & 0.31 & 0.15 & 0.08 & 0.05 \\ 0.37 & 0.33 & 0.19 & 0.08 & 0.03 \\ 0.85 & 0.77 & 0.18 & 0.02 & 0.02 \end{pmatrix} = (0.323\ 0.303\ 0.200\ 0.097\ 0.033) \quad (14)$$

Lastly, the final comprehensive evaluation result for the PE teacher could be determined by an weighted average value. The evaluation grades were assigned into numbers, for example, "good" = 99, "fairly good"= 89, "average"= 79, "poor"= 69, and "very poor"= 59, forming another set of V where $V = (99\ 89\ 79\ 69\ 59)$.

Supposing the final comprehensive evaluation result was Q, then

$$Q = W * V = (0.323\ 0.303\ 0.200\ 0.097\ 0.033) * (99\ 89\ 79\ 69\ 59) = 83.834 \quad (15)$$

Therefore, the final comprehensive evaluation of the PE teacher was 83.834, and the corresponding grade was "good" because it fell in the interval of "80-89" according to the abovementioned "quantitative criteria" in the "evaluation criteria".

Likewise, all-around, multi-level, and systematic comprehensive evaluations could be made to other PE teachers with fuzzy comprehensive evaluation method. Furthermore, the PE teachers' professional capacities could be ranked, providing a reference for performance management, promotion, and training.

IV. CONCLUSIONS AND SUGGESTIONS

1) The evaluation system for college PE teachers was a comprehensive evaluation system regarding to teachers ability, quality, and knowledge, which was established under the special economic conditions and PE teaching environment in Guangzhou in order to advance the development of the physical education in this area and improve the students physical fitness.

2) The evaluation system for college PE teachers was established based on the multi-level evaluation indexes, Analytic Hierarchy Process, and a fuzzy comprehensive evaluation. The evaluation of professional capacities were computed by an equation, "Q=W*V", which provides a practical example for the future evaluations of college PE teachers.

3) The study was based on Analytic Hierarchy Process, and the evaluation system was scientific. However, to provide references for further research on this topic, it is suggested that empirical studies can be done in a certain range to verify the practicality and discover the existed problems.

4) Although the study was conducted in Guangzhou, the result can be applied and promoted because of the great similarity of physical education in regular institutions of higher learning.

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