

Evaluation of Physical Education Teaching Based on Analytic Hierarchy Process

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Abstract—The evaluation of physical education (PE) teaching plays an important role in improving the teaching quality and students' physical fitness. Taking five colleges in a Chinese province for example, this paper surveys the status quo of college PE teaching evaluation, and reveals several problems with the evaluation: the evaluation index system (EIS) is incomplete, and the subjects are not diverse. Based on the survey results and previous findings, questionnaire survey, the Delphi method, analytic hierarchy process (AHP), logic analysis, and mathematical statistics were combined to construct an EIS for college PE teaching evaluation, determine the weights of indices on each level, design a standard scale, and develop the evaluation framework and flow. The research results promote the development of college PE teaching, and provide a reference for reforming the teaching evaluation of other disciplines.

Keywords—analytic hierarchy process (AHP), physical education (PE) evaluation, status quo, evaluation index system (EIS)

1 Introduction

As the saying goes, “the body is the capital of the revolution.” Living in a fast-paced and highly competitive society, people must keep physical fitness to adapt to social development. In fact, physical fitness becomes a key indicator of the ability of talents [1]. Against this backdrop, physical education (PE) teaching gains prominence in subject education. The evaluation of PE teaching plays an important role in improving the teaching quality and students' physical fitness [2]. Nevertheless, the current evaluation system and method in China cannot catch up with the reform and development of PE teaching. It is now urgent for the education circle to develop a scientific and reasonable evaluation system for PE teaching.

After reviewing the relevant literature, it is discovered that comprehensive evaluation of PE education started early in foreign countries, which gives inspiration and reference for PE teaching evaluation in China. For example, the traditional single relative evaluation model has evolved into self-difference evaluation and absolute evaluation, supplemented with relative evaluation [3]. Meanwhile, the evaluation emphasis has shifted from terminal evaluation to the combination between process

evaluation and terminal evaluation, making PE teaching evaluation more scientific and rational [4].

So far, Chinese scholars have obtained fruitful results on PE teaching evaluation. In terms of time, the research on PE teaching evaluation can be divided into the preliminary phase (1985-1990), formal phase (1991-2000), and in-depth development phase (since 2001). The once empirical PE teaching evaluation in China is increasingly systematic, standardized, and open [5]. The evaluation contents cover the concepts and classes, influencing factors, evaluation index system (EIS), evaluation method, and status quo [6].

In general, China has an abundance of theoretical and practical results on PE teaching evaluation, which greatly promote PE teaching. However, the traditional evaluation method could not keep pace with the continuous updates of PE teaching. In-depth research is needed to evaluate PE teaching in a comprehensive, diverse, and scientific manner [7].

Based on the above analysis and previous findings, this paper adopts questionnaire survey, the Delphi method, analytic hierarchy process (AHP), logic analysis, and mathematical statistics to develop a new method for college PE teaching evaluation, and construct an EIS and an efficient evaluation system for college PE teaching education.

2 Status Quo Survey of College PE Teaching Evaluation

2.1 Objects and approach

This paper designs a questionnaire on the status quo of college PE education evaluation [8], which focuses on satisfaction, evaluation subjects, and evaluation contents. The questionnaire survey was conducted among the teachers and students of 5 colleges in a Chinese province. A total of 35 questionnaires were distributed to the teachers, and 520 to the students. In the end, the research team received 34 valid responses (97.14%) from the teachers, and 502 (96.54%) from the students.

2.2 Results analysis

Table 1 shows the results of the questionnaire survey. It can be observed that college PE teaching evaluation emphasizes teaching ability and learning situation over teaching environment and teaching files. Several issues are overlooked, including the research ability of teachers, and the learning interest, learning attitude, and physical fitness of students. As a result, most teachers stress the academic performance, failing to put students at the center of the course. Therefore, the current PE teaching evaluation is incomplete and not objective enough.

Figure 1 shows the subjects of college PE teaching evaluation. Currently, college PE teaching is mainly evaluated by college experts and leaders, as well as students. The comments of PE teachers and their peers have not been fully considered.

Table 1. Results of questionnaire survey

Items	Teachers (%)	Students (%)
Teaching ability	67.8%	89.4%
Teacher morality	53.2%	47.6%
Teacher professional knowledge	61.5%	79.6%
Teacher research ability	35.4%	12.5%
Teaching files	42.5%	21.4%
Academic performance	82.4%	95.3
Learning interest	52.3%	47.8%
Learning attitude	62.2%	43.9%
Student physical fitness	32.1%	29.6%
Teaching environment	12.4%	15.1%
Teaching facility	22.9%	31.4%

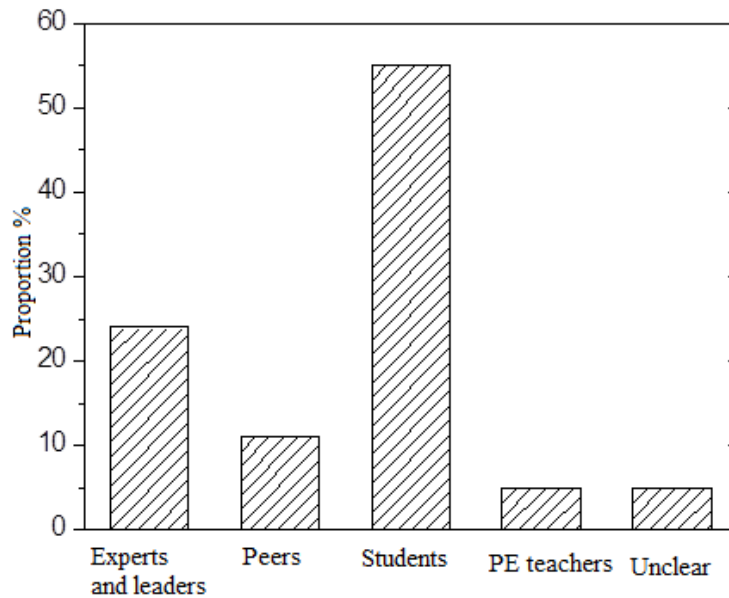


Fig. 1. Evaluation subjects

Figure 2 shows how satisfied the teachers and students are with college PE teaching evaluation. It is clear that 29.4% and 34.3% of college teachers and students are satisfied and strongly satisfied, respectively; 8.8% and 7.2% are dissatisfied and strongly dissatisfied, respectively. This further indicates the necessity for further improvement to the current college PE teaching evaluation.

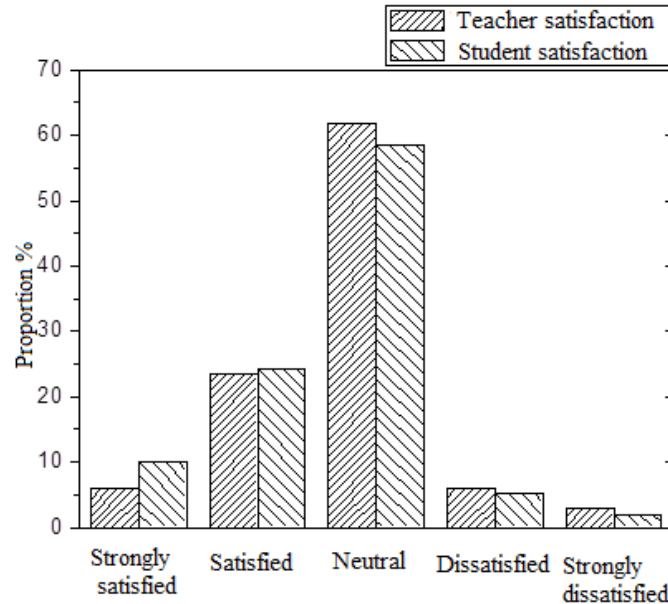


Fig. 2. Satisfaction with college PE teaching evaluation

3 AHP-Based Evaluation System

3.1 Objects and approach

The status quo survey reveals several problems with college PE teaching evaluation: the EIS is incomplete, and the subjects are not diverse. To realize scientific and reasonable evaluation of college PE teaching, this paper designs the evaluation indices and their weights for college PE teaching, laying the basis for an efficient evaluation system [9]. The indices were selected and weighed through the following methods: questionnaire survey, the Delphi method, analytic hierarchy process (AHP), logic analysis, and mathematical statistics.

3.2 EIS

Drawing on the relevant studies at home and abroad, this paper sets up a preliminary EIS for college PE teaching, which consists of 5 primary indices and 25 secondary indices (Table 2) [10]. The preliminary EIS was evaluated in two rounds by 20 teachers, experts, and leaders from the target colleges. All of them have been engaging in the teaching and management of PE. Table 3 shows the number of questionnaires distributed and received in the two rounds.

After the first round of expert survey, the coefficients of variation (COVs) for the five primary indices were all smaller than 0.25, indicating that the primary indices are

recognized by the experts, and need no adjustment. However, five out of the 25 secondary indices had COVs greater than 0.25, namely, A15, A43, A34, A51, and A52. Therefore, the secondary indices must be further adjusted. Drawing on expert comments, the authors deleted A15, A43 and A34, and merged A51 and A52 into student exercise awareness A51.

Table 4 shows the revised EIS, which contains 5 primary indices and 21 secondary indices. The new EIS was subjected to the second round of expert survey. The COVs for all 21 secondary indices were smaller than 0.25, suggesting that all secondary indices are recognized by the experts and need no adjustment.

Table 2. Preliminary EIS

Primary indices	Secondary indices
Teachers (A ₁)	Professional knowledge (A ₁₁)
	Basic teaching skills (A ₁₂)
	Morality (A ₁₃)
	Teaching attitude (A ₁₄)
	Lesson preparation (A ₁₅)
	Research ability (A ₁₆)
	Creativity (A ₁₇)
Teaching process (A ₂)	Teaching contents (A ₂₁)
	Teaching method (A ₂₂)
	Teaching organization (A ₂₃)
	Classroom atmosphere (A ₂₄)
Teaching files (A ₃)	Syllabus (A ₃₁)
	Teaching plan (A ₃₂)
	Instructional technology (courseware, video, etc.) (A ₃₃)
	Unit/lesson plan (A ₃₄)
	Teaching evaluation method (A ₃₅)
Teaching environment (A ₄)	Teaching venue (A ₄₁)
	Sports equipment (A ₄₂)
	Teaching atmosphere (A ₄₃)
Teaching effects (A ₅)	Learning interest (A ₅₁)
	Learning attitude (A ₅₂)
	Student motor skills (A ₅₃)
	Student theoretical knowledge (A ₅₄)
	Student physical fitness (A ₅₅)
	Student sportsmanship (A ₅₆)

Table 3. Data on two rounds of preliminary system evaluation

	Number of distributed questionnaires	Number of recovered valid questionnaires	Efficiency
First round	20	19	95%
Second round	20	20	100%

Table 4. Revised EIS

Primary indices	Weights	Secondary indices	Weights
Teachers (A ₁)	0.397	Professional knowledge (A ₁₁)	0.15
		Basic teaching skills (A ₁₂)	0.17
		Morality (A ₁₃)	0.17
		Teaching attitude (A ₁₄)	0.20
		Research ability (A ₁₅)	0.13
		Creativity (A ₁₆)	0.18
Teaching process (A ₂)	0.089	Teaching contents (A ₂₁)	0.29
		Teaching method (A ₂₂)	0.36
		Teaching organization (A ₂₃)	0.35
Teaching files (A ₃)	0.096	Syllabus (A ₃₁)	0.23
		Teaching plan (A ₃₂)	0.22
		Instructional technology (courseware, video, etc.) (A ₃₃)	0.30
		Teaching evaluation method (A ₃₄)	0.25
Teaching environment (A ₄)	0.157	Teaching venue (A ₄₁)	0.26
		Sports equipment (A ₄₂)	0.32
		Teaching atmosphere (A ₄₃)	0.42
Teaching effects (A ₅)	0.261	Student exercise awareness (A ₅₁)	0.30
		Student motor skills (A ₅₂)	0.21
		Student theoretical knowledge (A ₅₃)	0.15
		Student physical fitness (A ₅₄)	0.21
		Student sportsmanship (A ₅₅)	0.13

3.3 Index weighting

After the EIS was finalized, Satty’s 1-9 scale (Yang and Liu, 2021) was adopted for pairwise comparison between indices on the same level, and to construct a judgement matrix for each level. Table 5 shows the judgement matrix for primary indices.

Table 5. Judgement matrix for primary indices

A	A1	A2	A3	A4	A5
A ₁	1	4	3	3	2
A ₂	¼	1	1	1/2	1/3
A ₃	1/3	1	1	1/2	1/3
A ₄	1/3	2	2	1	1/2
A ₅	½	3	3	2	1

The judgement matrix can be written as:

$$A = \begin{bmatrix} 1 & 4 & 3 & 3 & 2 \\ \frac{1}{4} & 1 & 1 & \frac{1}{2} & \frac{1}{3} \\ \frac{1}{3} & 1 & 1 & \frac{1}{2} & \frac{1}{3} \\ \frac{1}{3} & 2 & 2 & 1 & \frac{1}{2} \\ \frac{1}{2} & 3 & 3 & 2 & 1 \end{bmatrix}$$

After normalization:

$$\bar{A} = \begin{bmatrix} 0.414 & 0.364 & 0.3 & 0.429 & 0.48 \\ 0.103 & 0.091 & 0.1 & 0.071 & 0.08 \\ 0.138 & 0.091 & 0.1 & 0.071 & 0.08 \\ 0.138 & 0.182 & 0.2 & 0.143 & 0.12 \\ 0.207 & 0.273 & 0.3 & 0.286 & 0.24 \end{bmatrix}$$

Adding up the elements row by row:

$$\overline{WA} = \begin{bmatrix} 1.986 \\ 0.446 \\ 0.480 \\ 0.783 \\ 1.305 \end{bmatrix}$$

After normalization:

$$WA = \begin{bmatrix} 0.397 \\ 0.089 \\ 0.096 \\ 0.157 \\ 0.261 \end{bmatrix}$$

Then, consistency test was carried out, using formulas $\lambda_{max} = \frac{1}{n} \sum_{i=1}^n \frac{\sum_{j=1}^n a_{ij} w_j}{w_i}$, $CI = \frac{\lambda_{max} - n}{n-1}$, and $CR = \frac{CI}{RI}$. The results show that $\lambda_{max} = 5.02$, $RI = 1.12$, $CI = 0.005124$, and $CR = 0.004575 < 0.1$. Therefore, our EIS passes the consistency test. Hence, the weight set of primary indices could be obtained as $WA = \{0.397, 0.089, 0.096, 0.157, 0.261\}$. The weights of secondary indices were determined by the same method. The weight of each index in our EIS is shown in Table 4.

3.4 Standard scale

To quantify and qualify college PE teaching, this paper designs an evaluation standard of five levels, namely, excellent, good, moderate, poor, and failed [12]. Based on the finalized EIS and index weights, a standard scale was developed for PE education teaching evaluation (Table 6) [13]. The subjects can evaluate the PE teaching against this standard scale. The score and level of each index could be

obtained by weighting the evaluation results. The overall score and level of PE teaching equal the weighted sum of indices on both levels.

Table 6. Standard scale

Primary indices and weights	Secondary indices and weights	Levels				
		Excellent (90-100)	Good (80-89)	Moderate (70-79)	Poor (60-69)	Failed (0-60)
Teachers (A ₁ 0.397)	Professional knowledge (A ₁₁ 0.15)					
	Basic teaching skills (A ₁₂ 0.17)					
	Morality (A ₁₃ 0.17)					
	Teaching attitude (A ₁₄ 0.20)					
	Research ability (A ₁₅ 0.13)					
	Creativity (A ₁₆ 0.18)					
Teaching process (A ₂ 0.089)	Teaching contents (A ₂₁ 0.29)					
	Teaching method (A ₂₂ 0.36)					
	Teaching organization (A ₂₃ 0.35)					
Teaching files (A ₃ 0.096)	Syllabus (A ₃₁ 0.23)					
	Teaching plan (A ₃₂ 0.22)					
	Instructional technology (courseware, video, etc.) (A ₃₃ 0.30)					
	Teaching evaluation method (A ₃₄ 0.25)					
Teaching environment (A ₄ 0.157)	Teaching venue (A ₄₁ 0.26)					
	Sports equipment (A ₄₂ 0.32)					
	Teaching atmosphere (A ₄₃ 0.42)					
Teaching effects (A ₅ 0.261)	Student exercise awareness (A ₅₁ 0.30)					
	Student motor skills (A ₅₂ 0.21)					
	Student theoretical knowledge (A ₅₃ 0.15)					
	Physical fitness (A ₅₄ 0.21)					
	Student sportsmanship (A ₅₅ 0.13)					

4 Evaluation Framework

Traditionally, PE teaching is usually evaluated by students and the manager of teaching department. However, teaching is an interactive process between teachers and students. Teachers, as the undertaker of teaching activities, have the best knowledge about the implementation of every teaching link and the performance of each student. Therefore, PE teachers should be included in PE teaching evaluation. Table 3 shows our framework of PE teaching evaluation [14].

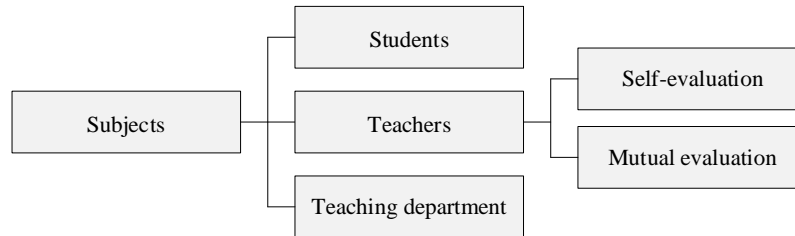


Fig. 3. Evaluation framework

As the receivers of PE teaching, students always provide the most convincing comments on PE teaching effects. In each semester, the students need to evaluate PE teaching twice: in the middle of the semester, and at the end of the semester. The two-stage evaluation offers the college and PE teachers the latest opinions of their students on PE teaching activities. Hence, they can make timely adjustment to these activities, making PE teaching more effective and efficient.

Teachers' evaluation of PE teaching can be divided into self-evaluation and mutual evaluation. The former helps PE teachers to identify and rectify their shortcomings. Thus, self-evaluation needs to be performed twice each semester. Mutual evaluation requires teachers to visit the class of each other, and understand the teaching philosophy of the other party. Through mutual evaluation, PE teachers can learn from each other through communication and exchanges. Therefore, mutual evaluation should be organized twice in each semester, in addition to the communication and exchanges with the target teacher after each class.

The teaching department of PE generally consists of experienced experts and professors, who are familiar with PE teaching theories and methods. Besides, they have a complete knowledge of the teaching materials and personal information of PE teachers. Thus, their evaluation is very authoritative. The evaluation by the teaching department is premised on class visits and student interviews.

5 Evaluation Flow

After analyzing the status quo of college PE teaching evaluation, this paper designs a PE teaching evaluation flow (Figure 4) [15]. PE teachers and the teaching department should arrange routine class visits and exchanges, carry out self-evaluation, mutual evaluation, and teaching department evaluation, and timely adjust the teaching method, contents, and environment according to the evaluation results. Meanwhile, the subjects, including students, teachers, and the teaching department, should perform evaluate PE teaching twice each semester on the PE teaching evaluation platform. The system will automatically collect, sort, and analyze the relevant data, and evaluate each index of PE teaching qualitatively and quantitatively. After learning the evaluation results, PE managers will feedback the results to PE teachers, students, and the teaching department via public notices, private talks, and online feedbacks, in the light of the results of daily class visits and the information of the relevant teachers. In this way, PE teachers, students, and the teaching department

will attach greater importance to PE teaching evaluation. Further, these subjects will be motivated to rectify the defects in a timely manner, which promotes the teaching quality of PE and physical fitness of students.

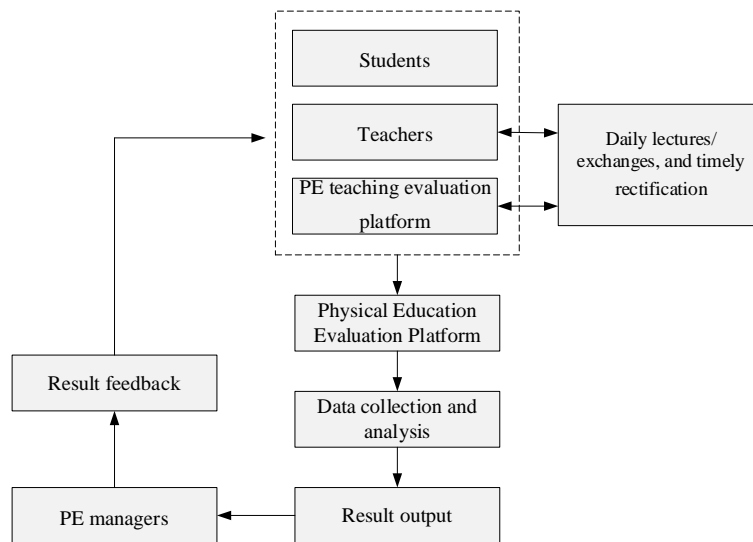


Fig. 4. Evaluation flow

6 Conclusions

The scientific and effective evaluation of PE teaching could drive the reform and innovation of PE, and greatly improve PE teaching quality. Therefore, this paper relies on AHP to develop a novel approach for PE teaching evaluation. The main conclusions are as follows:

1. Taking 5 colleges in a Chinese province for example, this paper carries out a status quo survey on college PE teaching evaluation, and discovers problems like incomplete EIS, and non-diverse subjects.
2. Based on the survey results and previous findings, questionnaire survey, the Delphi method, AHP, logic analysis, and mathematical statistics were adopted to construct an EIS for college PE teaching education, and assign a weight to each index.
3. To ensure the effectiveness of college PE teaching education, a standard scale was designed for the evaluation, followed by the establishment of the overall framework and specific flow.

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