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Physical education quality multilevel fuzzy evaluation model research based on PCA

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ABSTRACT

In order to improve physical education quality, strengthen education management and further stir up teachers working enthusiasm, it needs to provide one kind of scientific method to evaluate sports teachers' teaching; this paper takes physical education quality improvement as an example, put forward scientific method to carry out evaluation on sports teaching working quality, and use 4 classes sports performance testing the model. This paper totally establishes two models, in the first model it mainly adopts principal component analysis method, get more scientific sports teachers teaching comprehensive evaluation indicator by principal component analysis of 5 indicators; In the second model, through lots of data, carry out three levels indicator fuzzy evaluation on collecting objects, finally use normalization approach to get results.

Key words: Physical education quality, principal component analysis, fuzzy comprehensive evaluation

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INTRODUCTION

Analytic Hierarchy Process (called AHP for short) is a simple way that makes decisions on some more complicated, fuzzy problems. It is specially adapted to the problems that hard to quantitative analysis, is American operation expert professor T.L. Saaty presented a kind of simple, flexible and practical multi criterion decision method in 1970s. People in social, economic as well as scientific management field problems systematical analysis, they usually confront a complex and usually short of quantitative data system composed of mutual correlated, mutual restraint multiple factors [1]. Analytic hierarchy process provides a new, concise and practical model establishing method for such problems decision and sorting [2, 3].

Physical education evaluation system is an important method and way to measure sports teachers teaching work comprehensive levels, and also is an important path to implement scientific management of physical education. Previous evaluation on physical education, normally it adopts combining implementation with experts' evaluation, colleagues' mutual evaluation as well as students' evaluation on teaching such three ways. In evaluation process, people factors have large influences, evaluation results may have bigger differences from actual statuses, therefore it is hard to reflect its reality and equality, or even may influence sports teachers' teaching enthusiasm so that not helpful for carrying out sports teaching [4, 5].

Physical education has bigger differences from other theoretical courses; physical education is basically carrying out in sports court, meanwhile the teaching objects cover every major every level student in school, therefore factors defining in education evaluation is more difficult. After defining factors, it is also unpractical to carry out all quantization on it, so it should go ahead with combined method of qualitative and quantitative when carrying out physical education. In order to overcome traditional evaluation method shortcomings, the research uses principal component analysis method to carry out physical education evaluation, which is a fuzzy evaluation method that can effectively reduce subjective factors influences and its evaluation results more accurate and fair.

PRINCIPAL COMPONENT ANALYSIS MODELS

This paper through principal component analysis method selects minor uncorrelated new indicators to substitute large quantity and correlated indicators, and it can reflect original indicator information. Presently education evaluation on sports teachers mainly adopts ultimate evaluation, which is only using students test results to evaluate a teacher. Under such evaluation way, how to analyze students' test results so that can more scientific reflect teachers teaching? This paper considers the absolute indicator and relative indicator that reflect students' physical levels. Implement principal component analysis on these defined indicators, so that define teachers teaching evaluating comprehensive evaluation value. Usually, when evaluates teachers teaching, except for referencing students' results, it also collects other data. Therefore, this paper brings into teachers' evaluation indicators that got from questionnaires survey; it divides into main factors and sub factors. Due to it is very difficult to use exact numbers to measure these indicators evaluation which bears the features of vagueness, this paper applies multilevel fuzzy comprehensive evaluation method to analyze lots of fuzzy information, and further get comprehensive evaluation of teachers [6].

Principal component analysis method

Principal component analysis is a kind of statistical analysis method that converts original multiple variables into minor few comprehensive indicators. From the perspective of mathematics, it is a kind of dimensionality reduction technique. Assume that there are n pieces of geographic samples; each sample total has p pieces of variables descriptions so that it composes into a $n \times p$ steps geographic data array;

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1p} \\ x_{21} & x_{22} & \cdots & x_{2p} \\ M & M & \cdots & M \\ x_{n1} & x_{n2} & \cdots & x_{np} \end{bmatrix}$$

How to grab geographic things inner regularity from so many variables? To solve the problem, naturally it should make investigation in p dimensions space, which is very troublesome. To overcome such difficulty, it needs to do dimensionality reduction which is using less several comprehensive indicators to substitute original more variable indicators, while these less comprehensive indicators can reflect original more indicators reflected information as much as possible, meanwhile they are independent from each other. Then, how to select these comprehensive indicators (that are new variables)? Obviously, its simplest form is taking original variable indicators linear combination, properly adjust combination coefficients so that enable best mutual independence and representative ness among new variable indicators.

If record original variable indicators as $x_1, x_2, \cdots, x_i$, their comprehensive indicators-new variable indicators are $x_1, x_2 \cdots z_m (m \le p)$. Then:

$$\begin{cases} x_1 - l_{11}x_1 + l_{12}x_2 + \cdots + l_{1p}x_p \\ x_2 - l_{21}x_1 + l_{22}x_2 + \cdots + l_{2p}x_p \\ \cdots\cdots\cdots \\ z_m - l_{m1}x_1 + l_{m2}x_2 + \cdots + l_{mp}x_p \end{cases}$$

z_1 is the maximum variance in all linear combinations of $x_1, x_2, \cdots, x_p$; z_2 is z_1 uncorrelated maximum variance in all linear combinations of $x_1, x_2, \cdots, x_p$; z_m is both $z_1, z_2, \cdots z_{m-1}$ and $x_1, x_2, \cdots, x_p$ uncorrelated maximum variance in all linear combinations of $x_1, x_2, \cdots, x_p$.

The defined new variable indicators $z_1, z_2, \cdots, z_m$ in this way are respectively called original variable indicators $x_1, x_2, \cdots, x_p$ first, second, …, the m principal component. From which, z_1 accounts for the largest proportion in total variances, $z_2, z_3, \cdots, z_m$ variance deceases successively. During practical problems analyzing, it usually selects previous largest principal components, in this way reduce variables quantity and also grab major contradiction, and simplify variables relations.

From above analysis, it is clear that find out principal component is to define original variables $x_j(j=1,2,\cdots,p)$ loading $1_{ij}(i=1,2,\cdots,m;j=1,2,\cdots,p)$ in principal component $z_i(i=1,2,\cdots,m)$,they are respectively $x_1,x_2,\cdots,x_p$ correlated matrix m pieces larger feature values corresponding feature vectors.

Applications in physical education quality evaluation

Input original data each individual's values into above each principal component linear combination formula one by one, get each subject principal component scores. Absolute indicators that reflect teachers teaching through students' n times sports test results are:

(1) Use average scores to reflect the teacher teaching class overall level:

$\overline{c}$ =n times test total performance (n times numbers of people participate the test)

(2) Use variance to reflect the teacher teaching class dissolution degree

$$\sigma = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(c_i-\overline{c})^2}$$

(3) Now we accept mass education, one of teachers' important teaching tasks is let students master basic knowledge, therefore teaching evaluation should consider pass rate:

α =n times test qualified numbers of people (n times numbers of people participate the test)

(4) Another indicator reflects teachers' teaching capacity is excellent rate:

β =n times test excellent numbers of people (n times numbers of people participate the test)

(5) Learning impetus comes from performance progress, evaluate a teacher should consider progressive rate:

$$\gamma=\sum_{i=1}^{n-1}\frac{E_i}{N_i}$$

Through five indicators principal component analyzing can get more scientific sports teachers teaching comprehensive evaluation values indicator E . A,B,C,D Four classes principal component factors as following;

Progressive rate: x_1 = (0.666667 0.454545455 0.675676 0.774194);

Pass rate: x_2 = (0.930555556 0.909090909 0.932432432 0.983870968);

Excellent rate: x_3 = (0.152777778 0.227272727 0.135510511 0.241935484);

Average value: x_4 = (74.59722222 76.25 73.32432432 76.67741935);

Standard deviation: x_5 = (5.103538321 8.8705975 6.480966119 5.139267531);

Step 1, respectively determine estimated teachers' class i (i =1, 2, 3, 4) the j (j =1, 2, 3, 4, 5) indicator x_{ij} , so that establish original data matrix X :

$$X=\begin{bmatrix}x_1\\x_2\\x_3\\x_4\\x_5\end{bmatrix}^T=\begin{bmatrix}0.66667 & 0.93056 & 0.15278 & 74.597 & 5.1035\\0.45455 & 0.90909 & 0.22727 & 76.25 & 8.8706\\0.67568 & 0.93243 & 0.13551 & 73.324 & 6.481\\0.77419 & 0.98387 & 0.24194 & 76.677 & 5.1393\end{bmatrix}$$

Step 2, to eliminate dimensions influences among indicators, make standardization, get standardize matrix Z , from

which $Z_{ij}=(x_{ij}-\overline{x_i})/s_j$ .Further establish feature equation between x_i and x_j relative matrix V, get its feature root as $(\lambda_1,\lambda_2,\cdots\lambda_p)$, then let $q_i=\frac{\lambda_i}{\sum\lambda_i}$ and get contribution rate q_i, computational results as below Table1.

Table 1: Standardization results

Component analysis	Feature root λ_i	Contribution rate q_i
$(x_1)1$	2.36259	0.47252
$(x_2)2$	1.35642	0.27128
$(x_3)3$	1.281	0.2562
$(x_4)4$	0	0
$(x_5)5$	0	0

Step 3, By Jacobi iteration orthogonal transformation; work out corresponding feature vector matrix as

$$\begin{bmatrix} 0.29714 & 0.47187 & -0.43607 & -0.64782 & 0.28146 \\ -0.41695 & 0.63211 & 0.065738 & -0.056332 & -0.64738 \\ 0.73834 & -0.16843 & -0.083372 & -0.0092981 & -0.64765 \\ 0.25441 & 0.47054 & -0.31631 & 0.75816 & 0.1975 \\ 0.35776 & 0.35776 & 0.83577 & -0.047567 & 0.20791 \end{bmatrix}$$

Step 4, make use of Matlab, and work out score matrix as

$$\begin{bmatrix} -1.6257 & -0.065298 & -0.019943 & -1.711 \\ 0.11259 & 0.78723 & -0.33308 & 0.56674 \\ 0.17744 & 0.0092437 & 0.85307 & 1.0398 \\ 0.40092 & -0.73449 & -0.42562 & -0.75919 \end{bmatrix}$$

From score matrix can work out E (A)= -3.4219, E(B)= 1.1335, E(C)= 2.0796, E(D)= -1.5184.Through above analysis get comprehensive evaluation value, the larger value shows the higher teachers teaching level. By above data get that Class C is the best, Class B is the secondary, and then class D is the next, while Class A is the worst.

MULTILEVEL FUZZY COMPREHENSIVE EVALUATION MODEL

Multilevel fuzzy theory

Given factor discourse domain U is compose of k levels($k\geq 2$) , the first level(the top level) owns m pieces of factors $U=(U_1^{(1)}\quad U_2^{(1)}\quad\cdots\quad U_m^{(1)})$ its remark set is $V=(v_1\quad v_2\quad\cdots\quad v_n)$, then multilevel fuzzy comprehensive evaluation mathematical model is (without generality, take k=4) : $B=A.R$, In formula A is each level weight vector, from which subscript numbers x represents that A is the level x+1 each weight vector； R is the bottom level (the level k) fuzzy correlation matrix. Multilevel fuzzy comprehensive evaluation starts from the bottom level (the level k); calculate upwards by level, till get final remarks set B. The level k evaluation result is the level k-1 level factor membership. The calculation steps are:

(1) Carry out the fourth level calculation, respectively get like:

$$B_{111}=A_{111}.R_{111}$$
$$B_{112}=A_{112}.R_{112}$$
$$\vdots$$
$$B_{11s}=A_{11s}.R_{11s}$$
$$\vdots$$
$$\vdots$$
$$B_{mq1}=A_{mq1}.R_{mq1}$$
$$B_{mq2}=A_{mq2}.R_{mq2}$$
$$\vdots$$
$$B_{mqo}=A_{mqo}.R_{mqo}$$

After completing the level 3 calculation, let $R_1 = \begin{pmatrix} B_{11} \\ B_{12} \\ \vdots \\ B_{1p} \end{pmatrix}$, $\cdots$, $R_m = \begin{pmatrix} B_{m1} \\ B_{m2} \\ \vdots \\ B_{mq} \end{pmatrix}$

$$B_1 = A_1.R_1$$
$$\vdots$$

(2) Carry out the second level calculation, respectively get $B_m = A_m.R_m$, after completing the second level calculation, let $R = \begin{pmatrix} B_1 \\ \vdots \\ B_m \end{pmatrix}$.

(3) Carry out top level calculation, get final remark set $B = A \circ R$, after getting remark set, implement quantization handling.

Teaching quality evaluation applications

Presently university sports teacher teaching evaluation mainly adopts ultimate evaluation, which is only using students' test results to evaluate one teacher. Under this evaluation way, how to analyze students' test results so as to more scientific reflect teachers' teaching? This paper considering reflect students' sports level absolute indicator and relative indicator. Carry out principal component analysis of these defined indicators so that define teachers' teaching evaluation comprehensive evaluation values. And to teachers teaching evaluation, except for referencing students' performance, it will also collect other data, therefore this paper introduces other indicators with regard to teachers evaluation(divides into main factors and sub factors).Due to it is difficult to measure these indicators evaluation with exact numbers which bears vagueness, this paper applies multilevel fuzzy comprehensive evaluation to analyze lots of fuzzy information, further get comprehensive evaluation on teachers, evaluation system refers to Table 1.

Step 1, extract a sports teacher teaching quality evaluation investigation table, each indicator backwards bracket number is the indicator weight (assume students, evaluation group teachers have already filled out evaluation table, data as below table 2)

Table 1: Sports teaching quality evaluation indicator system

The first level	The second level(main factor)	The third level(sub factor)
Teaching quality	teaching attitude F1(0.2)	sufficient degree of course preparation F11(0.3)
		teaching log records F12(0.3)
		homework correction as well as after-school tutoring F13(0.4)
	Teaching content F2(0.3)	complete syllabus requests F21(0.2)
		after-school materials and teaching material combination F22(0.4)
		Implementation of class discussion F23(0.4)
	Teaching strategies and methodF3(0.2)	students sports interest motivation F31(0.4)
		sports class teaching appropriateness F32(0.3)
		Target to differences guidance, focus on teaching students according to aptitude F33(0.3)
	Teaching effects F4(0.3)	Daily testing results F41(0.4)
		Sports communication and application ability F42(0.4)
		Classroom attending rate as well as homework hand-in rate F43(0.2)

Table 2- students and teachers attend lecture grades evaluation each indicator count

Main factor	Sub factor	Students evaluation(100 people)					Teachers attend lecture evaluation(2 people)				
		excellent	good	normal	poor	bad	excellent	good	normal	poor	bad
Teaching attitude F1(0.2)	F11(0.3)	46	24	26	4	0	1	1	0	0	0
	F12(0.3)	42	20	32	4	2	1	0	1	0	0
	F13(0.4)	20	18	50	10	2	0	0	1	1	0
Teaching content F2(0.3)	F21(0.2)	34	26	18	22	0	0	1	1	0	0
	F22(0.4)	18	29	36	17	0	0	0	1	1	0
	F23(0.4)	17	18	36	28	1	0	0	1	1	0
teaching strategy and method F3(0.2)	F31(0.4)	48	24	18	10	0	0	2	0	0	0
	F32(0.3)	40	28	30	2	0	1	0	1	0	0
	F33(0.3)	28	34	29	8	1	0	2	0	0	0
Teaching effect F4(0.3)	F41(0.4)	50	26	20	3	1	2	0	0	0	0
	F42(0.4)	16	24	31	25	4	0	0	2	0	0
	F43(0.2)	46	26	22	6	0	1	0	1	0	0

Step 2, analyze collect objects fuzzy evaluation on the third level indicator, as Table 3.

Table 3-100 students fuzzy evaluation on indicator F11(course preparation sufficient degree)

evaluation grades	excellent	good	normal	poor	bad
Numbers of people	46	24	26	4	0
Percentage	0.46	0.24	0.26	0.04	0.00

The evaluation results can use fuzzy set recording as R111= (0.46, 0.24, 0.26, 0.04, 0.00). Similarly, it can determine 100 students' fuzzy set on indicators F12、F13 fuzzy evaluation:

R112= (0.42, 0.20, 0.32, 0.04, 0.02)
R113= (0.20, 0.18, 0.50, 0.10, 0.02)

Accordingly can get students single factor evaluation matrix on indicator F1:

$$R11=\begin{bmatrix} 0.46 & 0.24 & 0.26 & 0.04 & 0.00 \\ 0.42 & 0.20 & 0.32 & 0.04 & 0.02 \\ 0.20 & 0.18 & 0.50 & 0.10 & 0.02 \end{bmatrix}$$

Step 3, analyze collect objects fuzzy evaluation on the second level indicator. Teaching attitude F1 four indicators weight distributions are F11(0.3)、F12(0.3)、F13(0.4), can use fuzzy set represents as A11=(0.3,0.3,0.4).It can be concluded that 100 students' comprehensive evaluation on F1 as:

$$B11'= (0.3, 0.3, 0.4).\begin{bmatrix} 0.46 & 0.24 & 0.26 & 0.04 & 0.00 \\ 0.42 & 0.20 & 0.32 & 0.04 & 0.02 \\ 0.20 & 0.18 & 0.50 & 0.10 & 0.02 \end{bmatrix} = (0.3440\ 0.2040\ 0.3740\ 0.0640\ 0.0140)$$

Carry out normalization handling with evaluation result B1, get from 0.3440+0.2040+0.3740+0.0640+ 0.0140=1

$$B11=\left(\frac{0.3440}{1},\frac{0.2040}{1},\frac{0.3740}{1},\frac{0.0640}{1},\frac{0.0140}{1}\right) = (0.3440\ 0.2040\ 0.3740\ 0.0640\ 0.0140)$$

The normalization result shows that in 100 students, 34.40% students evaluation on the teacher teaching attitude as "excellent", 20.40% evaluation as "good", 37.40% evaluation as "normal", 6.40% evaluation as " poor", 1.40% evaluation as "bad". Similarly, it can get the 100 students comprehensive evaluations on teaching content F2, teaching strategies and methods F3 and teaching effects F4.

B12= (0.2008 0.24 0.324 0.24 0.004)
B13= (0.3960 0.2820 0.2490 0.0700 0.0030)
B14= (0.3560 0.2520 0.2480 0.1240 0.0200)

Accordingly it can get:

$$R_1 = \begin{bmatrix} 0.3340 & 0.2040 & 0.3740 & 0.0640 & 0.0140 \\ 0.208 & 0.24 & 0.324 & 0.224 & 0.004 \\ 0.3960 & 0.2820 & 0.2490 & 0.0700 & 0.0030 \\ 0.3560 & 0.2520 & 0.2480 & 0.1240 & 0.0200 \end{bmatrix}$$

Therefore,

$$\text{B1=A1.R1= (0.2 0.3 0.2 0.3).} \begin{bmatrix} 0.3340 & 0.2040 & 0.3740 & 0.0640 & 0.0140 \\ 0.208 & 0.24 & 0.324 & 0.224 & 0.004 \\ 0.3960 & 0.2820 & 0.2490 & 0.0700 & 0.0030 \\ 0.3560 & 0.2520 & 0.2480 & 0.1240 & 0.0200 \end{bmatrix} = (0.3172\ 0.2448\ 0.2962\ 0.1312\ 0.0106)$$

B1 is students' comprehensive evaluation on the teachers, which indicates 31.72% students evaluation on the teacher as " excellent", 24.48% evaluations are " good", 29.28% evaluations as " normal", 13.12% evaluations as "poor", 1.06% evaluations as " bad". Similarly, teachers that attend the lecture fuzzy comprehensive evaluation results on the teacher are:

B2= (0.2400 0.2000 0.4000 0.1600 0.0000)

$$\text{R1'=} \begin{bmatrix} 0.3150 & 0.2423 & 0.2928 & 0.1289 & 0.0210 \\ 0.2400 & 0.2000 & 0.4000 & 0.1600 & 0.0000 \end{bmatrix}$$

Therefore $R = \begin{pmatrix} 0.4 & 0.6 \end{pmatrix} \circ R_1^{'} = (0.2700\ 0.2169\ 0.3571\ 0.1476\ 0.0084)$

Now value each remark scores : "excellent" ——90~100 ； "good"——80~89 ； "normal"——70~79 ； "poor"——60~69；"bad"——50~59. Therefore, it gets scores after fuzzy comprehensive evaluation by students and teachers attend lectures on the teacher (extract middle values in every score grade):

$$G = 0.27088 * 95 + 0.21792 * 85 + 0.35848 * 75 + 0.14848 * 65 + 0.00424 * 55 = 81.027$$

Belongs to grade "good".

If make evaluation on a batch of teachers, model one through principal component analysis get one comprehensive evaluation value with students' scores as objective basis, then combining above achieved fuzzy comprehensive evaluation scores. This paper can analyze principle component again get the two weights, result is a more scientific ultimate comprehensive evaluation value. The size of value directly reflects teachers teaching level, the bigger value is the higher teaching level would be.

CONCLUSION

For principal component analysis model, this paper firstly solved five indicators as average scores that reflect the teacher teaching class overall levels, variance that reflects the teacher teaching class dissolution degree, students' test pass rate, excellent rate that reflects teachers' teaching ability and progressive rate. Through principal component analyzing them, got more scientific sports teachers' comprehensive evaluation value indicators. Then it tested the model. Finally through above analysis, this paper got comprehensive evaluation value, the bigger value represented the higher teacher teaching level. From above data, it can get: Class C is the best, Class B is the secondary, and then class D is the next, while Class A is the worst.

For multilevel fuzzy comprehensive evaluation model, this paper first analyzed students and teachers that attended lectures grades evaluation each indicator counts data, then respectively analyzed collected objects fuzzy evaluation on the third level indicator, collected objects fuzzy evaluation on the second level indicator, implemented normalization handling with them, finally got that the teacher belonged to good grade after students and teachers that attended lectures fuzzy comprehensive evaluation on the teacher.

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