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Assessment of students' physical education teaching using an improved TOPSIS method

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ABSTRACT: The way society is developing means there will be an increasing requirement for future students to show greater prowess in physical abilities. Physical education is a compulsory course for students who are in higher normal colleges. It is an important course for training students to become qualified teachers. Based on the analysis of the existing methods of evaluating students, a revised evaluation method is proposed using an improved TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method. This avoids the problem of the positive ideal solution and negative ideal solution being too close to the evaluated problem, which improves the traditional TOPSIS method.

INTRODUCTION

Physical education in colleges and universities has three aspects: 1) to teach students the basic theory of physical education; provide basic practical training in physical education; promote the ability to teach physical education; 2) provide a scientific basis for the educational theory underlying physical education; to enable students who will go on to become teachers to learn and master various teaching methods and lay a good theoretical foundation for the subject; and 3) to guide students toward using their knowledge of physical education to improve their learning ability and constantly improve their physical wellbeing.

The evaluation of students is carried out by education administrative departments or schools to judge and evaluate them according to standards established for the student work. But, the existing evaluation method is basically qualitative, inefficient, and lacks a scientific basis.

The work reported in this article used the TOPSIS method (Technique for Order Preference by Similarity to Ideal Solution), first proposed in 1981 by C.L. Hwang and K. Yoon [1], to evaluate physical education teaching from the two aspects of teaching and practice. One factor is whether physical education students and students of other subjects communicate with each other regularly. Such communication can help guide students in an internship and in making preparation for that internship. This can help students to better grasp the practical teaching and play an important role in guiding their internship.

It also gives the student exposure to other areas of education and, hence, broader knowledge than that required for teaching physical education. This, in turn, mitigates the situation in which physical education teaching is seen as lacking content and being too general [2-4]. Students starting on their studies should attend middle school classes, so as to enrich their knowledge.

THE TOPSIS METHOD

The Technique for Order Preference by Similarity to Ideal Solution (TOPIS) uses the degree to which objects are close to an ideal to sort and evaluate the relative merits of different objects. The TOPSIS is an approximation method that is commonly used for the analysis of multi-criteria decisions. It is widely used in evaluating the quality of work or in evaluating the benefits of some work.

The TOPSIS method evaluates an object according to its geometric distance from the positive ideal solution and the geometric distance from the negative ideal solution. If the evaluated object is closest to the positive ideal solution and furthest from the negative ideal solution, then, it is the best object. Conversely, if the evaluated object is furthest from the positive ideal solution and closest to the negative ideal solution, then it is the worst. Each index of the positive ideal solution has an optimum value, while the index of the negative ideal solution has the worst value [5].

EVALUATION OF COLLEGE STUDENTS' PRACTICAL ABILITIES USING THE TOPSIS METHOD

Determination of Evaluation Index Weights for the TOPSIS Model

The weight coefficient is a whole that can be decomposed into several factors or indices, which are used to indicate the proportion of each factor in the whole, sorted by weight [6]. The weight of an index reflects the relative importance of that index. It is also the reflection of the importance of the index, i.e. more important and the larger the weight; less important and the smaller the weight.

The weight of each factor is usually subjective, based upon experience. This lacks scientific objectivity, thus making it difficult to be accurate. Training at colleges and universities was studied to identify the factors involved, with the weights determined using the scaling method proposed by Satty [7].

Constructing the Judgment Matrix for Each Layer

A quantitative grading method was used for the various factors at a level. A quantitative value was assigned according to the importance of the factor. A 1 to 9 scale was used as proposed by Satty [7]. A five-level qualitative grading method was used corresponding to very weak, weak, strong, very strong, extremely strong, with the corresponding assignments on the 1 to 9 scale being 1, 3, 5, 7, 9.

If one element is secondary to another element, the quantitative assignment can be in reverse order, i.e. 9, 7, 5, 3, 1. If the classification of a problem requires a greater precision than the above five levels provide, then, terms can be inserted for 2, 4, 6, 8, to produce a full nine-level scale.

The judgment matrix is established by considering each of the factors D_i and determining the degree of importance d_{ij} in its relationship to another factor D_j. Table 1 shows the structure of the judgment matrix.

Table 1: Structure of the judgment matrix.

	D_1	D_2	D_3	...	D_n
D_1	d_{11}	d_{12}	d_{13}	...	d_{1n}
D_2	d_{21}	d_{22}	d_{23}	...	d_{2n}
D_3	d_{31}	$d3_2$	d_{33}	...	d_{3n}
...	...	...	...	...	...
D_n	d_{n1}	d_{n2}	d_{n3}	...	d_{nn}

DETERMINATION OF THE WEIGHT OF A LAYER

First of all, calculate the components W_i of W by using square root:

$$wi = \left(\prod_{i=1}^{n} d_y \right)^{1/n} \quad i = 1, 2, \cdots, \quad n$$

Secondly, putting $w=(w^1,w^2,\ldots w^n)^T$ into the normalisation, producing the weight vector $w^0=(w_1^0 \text{，} w_2^0 \text{，} \ldots w_n^0)^T$

$$w_A = \sum_{i=1}^{n} w_i \qquad w_i^0 = w_i / w_A$$

Once again, calculating A's maximum characteristic root $\lambda_{\max}$ by:

$$\lambda_{\max} = \sum_{i=1}^{n} BW^0 \Big/ nw_i^0$$

for the i element.

DETERMINING THE COMBINATION WEIGHTS

Combination weight (CW) is the relative importance of bottom indices relative to the top (total goals). This process proceeds from the highest level to the lowest, layer by layer. If a hierarchy of A contains m factors A_1, A_2, $\ldots A_m$, the combination weights are a_1, a_2,$\ldots a_m$. If the next layer B contains n factors B_1, B_2, $\ldots B_n$, the layer weights of factor A_j are b_{1j}, b_{2j},$\ldots b_{nj}$.

DETERMINING THE WEIGHT OF EACH EVALUATION INDEX

The layer of the evaluation index for the students' practical teaching abilities is shown in Table 2. Five index factors in the first layer are: teaching, incentive, management, curriculum, evaluation. The judgment matrix values for the target layer for the five factors are shown in Table 2.

Table 2: Weight of each evaluation index.

Management factor 0.26					Incentive factor 0.19					Teaching factor 0.32			
D_{11}	D_{12}	D_{13}	D_{14}	D_{21}	D_{22}	D_{23}	D_{24}	D_{25}	D_{26}	D_{31}	D_{32}	D_{33}	D_{34}
0.49	0.10	0.18	0.25	0.17	0.11	0.30	0.25	0.14	0.08	0.33	0.43	0.17	0.08

Curriculum factor 0.15					Evaluation factor 0.11			
D_{41}	D_{42}	D_{43}	D_{44}	D_{45}	D_{51}	D_{52}	D_{53}	D_{54}
0.39	0.27	0.12	0.18	0.09	0.42	0.31	0.16	0.13

ANALYSING AND EVALUATING STUDENTS' PHYSICAL AND PRACTICAL ABILITIES

An evaluation of students in a college in Wuhan was undertaken as an example. The original data are shown in Table 3. In the table ($A_1, A_2, A_3, A_4, A_5, A_6, A_7, A_8, A_9, A_{10}$) are the teachers who were evaluated based on the included indicators.

Table 3: Original data for the evaluated teachers.

Index	Effect of teaching	Teaching hours	Main achievements			
Teacher	Students' evaluation	Experts' evaluation	Amount of theory (hours)	Amount of experiments (hours)	General evaluation of scientific research (points)	General evaluation of papers, textbooks and monographs (points)
A_1	excellent	good	110	86	7.5	4.0
A_2	excellent	excellent	130	70	9.5	5.5
A_3	good	medium	100	90	4.0	6.5
A_4	good	good	95	110	5.0	7.5
A_5	medium	good	75	105	6.5	4.5
A_6	medium	bad	55	125	2.5	6.0
A_7	bad	medium	120	80	9.5	5.5
A_8	good	medium	95	65	7.5	7.0
A_9	good	good	110	85	4.0	4.5
A_{10}	excellent	good	90	80	4.5	9.0

Fuzzy quantisation was used to map attribute values to language, e.g. *M* (bad) = 0.11, *M* (medium) = 0.50, *M* (good) = 0.73, *M* (excellent) = 0.89. The total hours of student participation in the evaluation was calculated as total hours = experimental class *0.7+ theory class. Thus, the evaluation index can be expressed as: students' evaluation, experts' evaluation, the total hours of teaching, the hours of practice, the hours of extracurricular activity, totalling five secondary indices. The data were, then, normalised to yield the $m \times n$ decision matrix Z with $m = 1, 2, \ldots, 10$ and $n = 1, 2, 3, 4, 5$ as:

$$= \begin{bmatrix} 1 & 0.78 & 0.79 & 0.63 & 0 \\ 1 & 1 & 1 & 0.92 & 0.26 \\ 0.78 & 0.49 & 0.46 & 0.13 & 0.54 \\ 0.78 & 0.78 & 0.76 & 0.35 & 0.72 \\ 0.49 & 0.78 & 0.26 & 0.56 & 0.17 \\ 0.49 & 0 & 0.07 & 0 & 0.46 \\ 0 & 0.49 & 0.89 & 1 & 0.35 \\ 0.78 & 0.49 & 0 & 0.70 & 0.63 \\ 0.78 & 0.78 & 0.96 & 0.20 & 0.17 \\ 1 & 0.78 & 0.12 & 0.28 & 1 \end{bmatrix}$$

The previously introduced determination method can be used to calculate the index weight: *W = {0.12, 0.12, 0.29, 0.24, 0.23}*; thus, determining the normalised weight of the decision matrix *X = WZ* as:

$$X = \begin{bmatrix} 0.121 & 0.094 & 0.231 & 0.153 & 0 \\ 0.121 & 0.121 & 0.289 & 0.221 & 0.061 \\ 0.094 & 0.059 & 0.135 & 0.033 & 0.126 \\ 0.094 & 0.094 & 0.222 & 0.085 & 0.167 \\ 0.061 & 0.094 & 0.077 & 0.136 & 0.040 \\ 0.059 & 0 & 0.021 & 0 & 0.103 \\ 0 & 0.059 & 0.260 & 0.239 & 0.082 \\ 0.094 & 0.059 & 0 & 0.169 & 0.146 \\ 0.094 & 0.094 & 0.282 & 0.051 & 0.042 \\ 0.121 & 0.094 & 0.039 & 0.071 & 0.231 \end{bmatrix}$$

DISTANCE TO THE POSITIVE AND NEGATIVE IDEAL SOLUTIONS

For the evaluation object (scheme) the distance to the positive and negative ideal solutions were calculated as:

$$D_i^+ = \prod x_i - x^+ \prod 2 = \prod x_i - \vee x \prod 2 = \sqrt{\sum_{=1}^{n} (x_{ij} - x_j^+)^2}, i = 1,2,\cdots,m;$$

$$D_i^- = \prod x_i - x^- \prod 2 = \prod x_i - \wedge x \prod 2 = \sqrt{\sum_{=1}^{n} (x_{ij} - x_j^-)^2}, i = 1,2,\cdots,m.$$

The relative closeness degree of the evaluation object was calculated as:

$$U_i = \frac{\prod x_i - \wedge x \prod 2}{\prod x_i - \wedge x \prod 2 + \prod x_i - \vee x \prod 2} = \frac{D_i^-}{D_i^- + D_i^+}, i = 1,2,\cdots,m.$$

Sort the evaluated personnel in order of U_i. When U_i tends to 1, the scheme is optimal. In this work, the comprehensive evaluation of the evaluated personnel was the best. The value of U_i determine the pros and cons of the evaluated personnel.

Using the above D+i, D-i, Ui, (i = 1,2,.. ,10) can be obtained, which shows the distance from the evaluation indices of each evaluated object to the positive ideal solution and to the negative ideal solution, as well as the relative closeness degree. See Table 4 for the results.

Table 4: Distance to the positive and negative ideal solutions and relative closeness degree.

Teacher	D_i^+	D_i^-	U_i	Sorting order
A_1	0.2534	0.3176	0.5561	4
A_2	0.1688	0.4079	0.7071	1
A_3	0.2845	0.2199	0.4359	8
A_4	0.1824	0.3215	0.6379	3
A_5	0.3089	0.1978	0.3903	9
A_6	0.4053	0.1216	0.2308	10
A_7	0.2010	0.3690	0.6472	2
A_8	0.3163	0.2512	0.4426	7
A_9	0.2704	0.3180	0.5403	5
A_{10}	0.3049	0.2874	0.4851	6

After having comprehensive evaluations of ten teachers on their student teaching and practical work, the results show that A_2 is the most outstanding teacher, and A_6 the worst, which is reflected in the students' comprehensive performance.

CONCLUSIONS

In this article, the current status of research methods into the evaluation of physical education students is summarised. An example evaluation was carried out using the TOPSIS method. Finally, this method was tested through the examples above to prove that it is a method that is convenient, practical and feasible. It was also objective, impartial and effective.

This method made full use of evaluation indexes for the given information. The idea and structure of the process is simple, easy to use and operate. The results of the evaluation also show the capabilities of this evaluation method.

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