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A Multiple Fuzzy Evaluation Model of Physical Education in General Colleges and Universities for Knowledge Engineering

Yue Zhang

Sport Department, Jiangsu University, Jiangsu, Zhenjiang, 212001, China.
zyuehome@163.com

In response to the fact that the physical education evaluation is unitary in evaluation content, has unclear target, fails to address comprehensive indexes and reaches general conclusion, this paper discusses the multiple evaluation of physical education in general colleges and universities. Firstly, based on the multiple intelligence theory, this paper analyzes the evaluation process of physical education and proposes a new evaluation index system for physical education in general colleges and universities. Secondly, by dealing with different indexes under the system and based on the fuzzy system theory, this paper constructs a multiple fuzzy evaluation model and obtains the fuzzy distance and fuzzy similarity between measured values of indexes and their corresponding classic domains, thus knowing the physical education ability and level in general colleges and universities. Last but not the least, a case involving physical education in a given university is discussed to verify the efficacy of the model.

1. Introduction

With quality education is applied to general colleges and universities, physical education have played an increasing role in higher education. The development of physical ability is becoming a key factor of measuring education quality of general colleges and universities. Physical quality has been a dominant indicator for measuring the effect of talent nurturing. Therefore, it is necessary to evaluate physical education in general colleges and universities and adopt reasonable and scientific mechanism and strategies to promote physical education quality [Xue et al (2010), Huang (2014) and Li (2014) reported]. Currently, studies on the evaluation of physical education in colleges and universities have reached fruitful results, promoting the improvement of teaching effect and efficiency [He (2013), Wang et al (2013), Wang et al (2011) and Zhang et al (2011) reported]. However, the evaluation work is still in its infancy and previous researches have certain limitations. For example the evaluation is unitary in evaluation content, has unclear target, fails to take teaching effect into consideration, overlooks key section in the teaching process, or the evaluation model and method may be objective and general. Therefore, based on the multiple intelligence theory [Nalan et al (2011) and Vîrtop (2014) reported], this paper analyzes the evaluation system of physical education in general colleges and universities and proposes a multiple fuzzy evaluation index system. At the same time, by using the fuzzy system theory [Hoseyn et al (2011), Kaveh et al (2013) and Chee et al (2015) reported], it constructs a multiple fuzzy evaluation model to evaluate physical education in general colleges and universities.

2. The Fuzzy Evaluation Index System of Physical Education in General Colleges and Universities

This paper analyzes eight dimensions of the multiple intelligence theory and specifies the evaluation indicator according to influential factors of physical education in colleges and universities. Table 1 shows the multiple evaluation index system.

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Table 1: The multiple evaluation index system of physical education in general colleges and universities

target layer	criteria layer	indictor layer
The fuzzy evaluation index system of physical education in general colleges and universities C	Verbal-linguistic intelligence C_1	Effectiveness of teaching content c_{11}
		Effectiveness of teaching method c_{12}
		Mastery degree of knowledge c_{13}
		Learning attitude c_{14}
	Musical-rhythmic intelligence C_2	Teaching planning c_{21}
		Progress control of leaning c_{22}
		Rhythm control c_{23}
	Logical-mathematical intelligence C_3	Development of innovative ability c_{31}
		Development of thinking ability c_{32}
	Visual-spatial intelligence) C_4	Insight of sport actions c_{41}
	Bodily-kinesthetic intelligence C_5	Effectiveness of teaching forms c_{51}
		Performance ability c_{52}
		Development of stamina c_{53}
		Development of athletic skills c_{54}
		Sport activity participation c_{55}
		Body health c_{56}
	Self-questioning intelligence C_6	Degree of completion of teaching tasks c_{61}
		Mental health c_{62}
		Social service c_{63}
		Social satisfaction c_{64}
	Interpersonal intelligence C_7	Development of coordination c_{71}
		Development of cooperation and teamwork c_{72}
	Naturalist intelligence C_8	Ability to reform c_{81}
		Social adaption c_{82}

3. Multiple Fuzzy Evaluation Model of Physical Education in General Colleges and Universities

3.1 Standardization of evaluation index

There are qualitative indicators and quantitative indicators. The qualitative indicator can be expressed by fuzzy membership or qualitative language description. The quantitative indicator can be obtained through measured data. To have unified scale, these indicators need to be subject to standardization.

(1) Standardization of qualitative indicator

If the value v_j of the qualitative indicator j can be obtained through fuzzy membership, suppose the corresponding fuzzy membership function is $\varphi(x)$. There are:

$$v_j = \varphi(x_j) \tag{1}$$

In particular, if the qualitative indicator j has reverse membership, there is:

$$v_j = 1 - \varphi\left(x_j\right) \tag{2}$$

If the value v_j of the qualitative indicator j can be obtained through fuzzy language description, it should be transformed to a value in the range 0-1. 1 refers to “excellent” and 0 refers to “poor”. So there are:

$$v_j = \left[v_j^a, v_j^b\right], \ 0 \le v_j^a \le v_j^b \le 1 \tag{3}$$

(2) Standardization of quantitative indicator

If the value u_j of the quantitative indicator j is measured data, the maximum value is u_j^{sup} and the minimum value is u_j^{inf}. When the quantitative indicator j is a positive indicator, its value v_j after standardization is:

$$v_j = \frac{u_j - u_j^{inf}}{u_j^{sup} - u_j^{inf}} \tag{4}$$

When the quantitative indicator j is a negative indicator, its value v_j after standardization is:

$$v_j = \frac{u_j^{sup} - u_j}{u_j^{sup} - u_j^{inf}} \tag{5}$$

In particular, if the value u_j of the quantitative indicator j is a measured interval, namely $u_j = \left[u_j^a, u_j^b\right]$, expression (4) should be rewritten to the following form:

$$v_j = \left[v_j^a, v_j^b\right] = \left[\frac{u_j^a - u_j^{inf}}{u_j^{sup} - u_j^{inf}}, \frac{u_j^b - u_j^{inf}}{u_j^{sup} - u_j^{inf}}\right] \tag{6}$$

Expression (5) should be rewritten to the following form:

$$v_j = \left[v_j^a, v_j^b\right] = \left[\frac{u_j^{sup} - u_j^b}{u_j^{sup} - u_j^{inf}}, \frac{u_j^{sup} - u_j^a}{u_j^{sup} - u_j^{inf}}\right] \tag{7}$$

3.2 Construction of classic domain

The multiple fuzzy evaluation of physical education usually has several grades, each corresponding to different values. To conduct the multiple fuzzy evaluation effectively, it is necessary to establish different classic domains of different evaluation grades. Suppose there are m grades in the evaluation of physical education, the classic domain G_{ij} of indicator j about evaluation grade i is:

$$G_{ij} = \left[g_{ij}^a, g_{ij}^b\right], \ g_{ij}^a \le g_{ij}^b \tag{8}$$

The classic domain G_{ij} is subject to standardization, as shown in Section 3.1 and gets:

$$H_{ij} = \left[h_{ij}^a, h_{ij}^b\right], \ 0 \le h_{ij}^a \le h_{ij}^b \le 1 \tag{9}$$

3.3 Weight of indicators

This paper adopts the Analytic Hierarchy Process (AHP) to allocate weight of indicators. According to experts’ experience and knowledge, the ratio scale of 1-9 is used to compare two indicators in the same layer and score them. As a result, the comparative judgment matrix $\boldsymbol{A}$ can be obtained:

$$\boldsymbol{A} = \left\{a_{ks}\right\}_{nxn} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \tag{10}$$

Where, $a_{ks} * a_{sk} = 1$.

By computing the maximum eigenvalue of judgment matrix, the characteristic vector of can be obtained.

$$\boldsymbol{A}X = \lambda_{max} X \tag{11}$$

$$X = \{x_1, x_2, \cdots, x_{n-1}, x_n\} \tag{12}$$

The characteristic vector is standardized to obtain the weight vector W :

$$W = \left\{ x_1 / \sum_{j=1}^{n} x_j, x_2 / \sum_{j=1}^{n} x_j, \cdots, x_{n-1} / \sum_{j=1}^{n} x_j, x_n / \sum_{j=1}^{n} x_j \right\} = \{w_1, w_2, \cdots, w_{n-1}, w_n\} \tag{13}$$

3.4 Establishment of the evaluation model and realization of the algorithm

Through abovementioned analysis, the unified measurement of indicator j of physical education evaluation can be obtained, which is $v_j = \left[v_j^a, v_j^b \right]$. The classic domain of indicator j about evaluation grade i can be identified, $H_{ij} = \left[h_{ij}^a, h_{ij}^b \right]$. Thus, the fuzzy Euclidean distance d_{ij} between the indicator j and the classic domain of indicator j about evaluation grade i is:

$$d_{ij} = \sqrt{\left(v_j^a - h_{ij}^a \right)^2 + \left(v_j^b - h_{ij}^b \right)^2} \tag{14}$$

The fuzzy similarity ξ_{ij} between the indicator j and the classic domain of indicator j about evaluation grade i is:

$$\xi_{ij} = 1 - d_{ij} \tag{15}$$

Considering the weight w_j of indicators, the weighed fuzzy similarity $\zeta_i^{\otimes}$ between the indicator j and the classic domain of indicator j about evaluation grade i is:

$$\zeta_i^{\otimes} = \sum_{j=1}^{n} \left(w_j * \xi_{ij} \right) \tag{16}$$

The larger $\zeta_i^{\otimes}$ is, the closer the object under evaluation is to evaluation grade i . Thus, according to weighed fuzzy similarity $\zeta_i^{\otimes}$, the evaluation grade of the object under evaluation can be identified.

4. Case Study and Model Verification

To promote physical education in key colleges and universities and improve physical education quality, a phase assessment on physical education in general colleges and universities of a province is practiced and taken as an example. This paper combines the statistical analysis, questionnaires; exert comprehensive evaluation method and student comprehensive evaluation method to evaluate the education performance of key colleges and universities of a province according to the evaluation index system. Table 2 shows relevant data for the evaluation.

Table 2: Evaluation indicators of physical education in general colleges and universities

criteria layer	Weight	indicator layer	Weight	Value
C_1	0.125	c_{11}	0.321	0.85
		c_{12}	0.321	0.80
		c_{13}	0.228	0.85
		c_{14}	0.130	0.75
C_2	0.125	c_{21}	0.600	0.80
		c_{22}	0.200	0.50
		c_{23}	0.200	0.60
C_3	0.125	c_{31}	0.500	0.40
		c_{32}	0.500	0.40
C_4	0.125	c_{41}	1.000	0.75
		c_{51}	0.161	0.80
C_5	0.125	c_{52}	0.161	0.75
		c_{53}	0.045	0.90
		c_{54}	0.045	0.80
		c_{55}	0.294	0.90
		c_{56}	0.294	0.80
C_6	0.125	c_{61}	0.200	0.90
		c_{62}	0.200	0.90
		c_{63}	0.300	0.90
		c_{64}	0.300	0.80
C_7	0.125	c_{71}	0.333	0.60
		c_{72}	0.667	0.80
C_8	0.125	c_{81}	0.500	0.50
		c_{82}	0.500	0.75

According to the evaluation standard of physical education in general colleges and universities, there are four grades, namely excellent, good, mediocre and poor. After standardization of indicators, the classic domain is constructed, as shown in Table 3.

Table 3: Classic domain of the evaluation of physical education in general colleges and universities

Evaluation grade	Classic domain
Excellent	0.90-1.00
Good	0.75-0.90
Mediocre	0.50-0.75
Poor	0-0.50

According to the Euclidean distance and fuzzy similarity between the indicator and the classic domain, the fuzzy similarity of indicators is obtained. Similarly, according to the calculation model proposed in this paper, the comprehensive fuzzy similarity between evaluation criteria and evaluation grade is computed, as shown in Table 4.

Table 4: Fuzzy similarity between evaluation criteria and evaluation grade

Evaluation criteria	Evaluation grade			
	Excellent	Good	Mediocre	Poor
C_1	0.803	0.883	0.670	0.118
C_2	0.638	0.772	0.732	0.266
C_3	0.220	0.390	0.636	0.588
C_4	0.708	0.850	0.750	0.209
C_5	0.808	0.869	0.633	0.133
C_6	0.863	0.861	0.611	0.055
C_7	0.685	0.814	0.737	0.228
C_8	0.534	0.689	0.750	0.355
Comprehensive fuzzy similarity	0.657	0.766	0.689	0.244

From Table 5, it can be seen the performance of physical education in key colleges and universities of this province is labeled as “good”, which is in line with the real assessment result. The case proves the model proposed has efficacy and feasibility.

5. Conclusions

This paper analyzes problems presenting in physical education and addresses the evaluation of physical education in general colleges and universities. It proposes an evaluation index system based on multiple intelligence theory. And according to the fuzzy system theory, this paper constructs a multiple fuzzy evaluation model to evaluate physical education in general colleges and universities. These two theories are proved to have good theoretical basis. The introduction of Euclidean distance reduces the complexity of calculation and produces reliable computing results. Through a case study, the model is proved to be worthy of widely application. It provides an effective way of evaluation of physical education in general colleges and universities.

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