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Evaluating students' skills in a physical education course using *grey system* theory

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ABSTRACT: Professional skills are important to students who major in physical education (PE). They must be able to conduct the tasks required by the teaching of physical activities. Evaluation of the student's skills can offer a theoretical basis for measuring a PE course, but an effective evaluation method is lacking. Therefore, an evaluation method based on the *grey system* theory is proposed in this article. First, the educational structure of the PE is discussed; second, the mathematical model of grey system theory is presented; and third, the structure of the professional skills evaluation model of students majoring in PE education is presented. The evaluation index system, the results of which are drawn from a questionnaire distributed to 800 students, and the evaluation programme, is put forward. A case study was carried out, the results of which show that the evaluation method outlined here can contribute to improving overall standards in the course.

INTRODUCTION

With the expansion of higher education in China, improving students' education is a key goal. Higher education should focus on developing both the innovative and practical abilities of students, as well as their personal and academic qualities. In recent years, there has been a high demand for students studying physical education (PE). Physical education skills are necessary for all sporting activities and students studying PE should have good practical skills for observation, expression and communication [1].

The PE student's professional goal is to teach and to provide guidance. At present there are disadvantages for the PE students in developing their skills and evaluating their abilities on PE courses. Reform of PE teaching must be continued and deepened, so as to improve students' skills [2].

The *grey system* theory, initiated in 1982, is the mathematical theory that solves problems where there is incomplete information [3]. The grey system theory can be used to crystallise and quantify the evaluation of students' abilities on PE courses. Conclusions can be drawn from the data even though all of the underlying rules are not understood.

Grey relational analysis is a new method in the grey system theory. In grey relational analysis a system with no information is *black* and a system with perfect information is *white*; these extremes are unlikely in real situations. Grey relational analysis is used to analyse the relationships between the various factors of a system.

The relational degree is a measure of the relationship between all factors and can be used to evaluate PE students' abilities. There are many uncertainties in evaluating the abilities of PE students, and this implies that students' abilities can be regarded as grey, and suitable for analysis using the grey system theory.

PRESENT LEVEL OF SKILL FOR STUDENTS MAJORING IN PHYSICAL EDUCATION

The abilities of students studying PE are poor and do not meet the requirements of colleges or society. This affects their employment opportunities. The problems with PE teaching are as follows [4]:

First, the structure of the curriculum is inappropriate and the basics are not properly emphasised. The time allocated to different components of the course is incorrect, and the theoretical and technical subjects are not properly arranged. The course content is bland and the scope is narrow.

Second, the teaching of the practical sessions is weak. The teaching of practicals is dominated by practice as it should be but should not be limited to it; for example, the graduate may be expected to engage in physical activities in society and in group fitness instruction. The range of the practical teaching is narrow and the time spent on it short. The time allocated to practicals is not adequate and the feedback is insufficient.

Third, extracurricular activities are not properly integrated into the course, with inadequate support for sports clubs and sports associations, etc. Therefore, the PE students are not being exposed to enough extracurricular opportunities.

Training is similar to systems engineering, in that it centres on the design and management of a complex project over a life cycle and an evaluation of the results, i.e. improving students' skills. The teaching of the PE could be evaluated to determine the main problems. Metrics could then be used to optimise the course structure to obtain the best outcomes for students.

THE MATHEMATICAL MODEL: GREY SYSTEM THEORY

The grey equation can be used to describe the characteristics and evolution of a grey system. The grey equation can be expressed as follows [5]:

The Grey Algebra Equation

The grey algebra equation includes grey coefficients. If the grey coefficients are limited in the bounded grey domain, then, the grey equations denote limited white equations. If the grey coefficients are infinite, the grey equations denote infinite white equations, i.e. black. The different grey coefficients relate to different solutions.

Grey Differential Equation

The grey differential equation is used to describe the grey system. The grey system has incomplete and uncertain information and its evolution is described by a series. The grey differential equation includes the grey derivative.

For a grey system, the time series reflects the behaviour of the system. The evolution at time i is expressed as follows [6]:

$$d^{(i)}(k_i) = x(k_i) - x(k_i - 1_i) \tag{1}$$

where $k_i = 1_i, 2_i, \cdots, n_i$, 1_i denotes a unit of time, $d^{(i)}(k_i)$ denotes the grey derivative of $d(k)$.

The data series that reflect the behaviour of the grey system is defined by $X^{(0)}$. $X^{(0)}$ determines the series $X^{(1)}$; the expressions for $X^{(0)}$ and $X^{(1)}$ are:

$$X^{(0)} = [x^{(0)}(1), x^{(0)}(2), \cdots, x^{(0)}(n)] \tag{2}$$

$$X^{(1)} = [x^{(1)}(1), x^{(1)}(2), \cdots, x^{(1)}(n)] \tag{3}$$

where $x^{(1)}(k) = \sum_{i=1}^{k} x^{(0)}(i)$, $k = 1, 2, \cdots, n$.

The grey derivative of $X^{(1)}$ is expressed as follows:

$$d(k) = x^{(0)}(k) \tag{4}$$

Based on the series $X^{(1)}$, the differential equation can be expressed as follows:

$$x^{(0)}(k) + az^{(1)}(k) = b \tag{5}$$

where $z^{(1)}(k)$ denotes the background value, which is expressed as follows:

$$z^{(1)}(k) = 0.5x^{(1)}(k) + 0.5x^{(1)}(k-1) \tag{6}$$

The grey differential equation satisfies the following conditions:

- The grey derivative with relative maximum information density is complete;
- The series is a grey differential series;
- The background value and the grey derivative have a flat relationship.

Grey System Analysis

The grey system analysis includes grey relational analysis, grey cluster analysis and grey decision analysis. The grey relational analysis can be applied to situations where the data are limited and grey. The basic idea is as follows: similarity of series curves is used to judge whether a relationship is close, and the grey relational degree is used to measure the closeness. Grey relational analysis requires limited calculations and yields reliable results; it has been used, for example, in engineering.

Grey cluster analysis gathers observations into several definable classifications according to the white weight function. Grey cluster analysis has two methods as follows: The first method is grey relational cluster analysis, which is applied when merging comparable factors to simplify a complex system.

An index can denote several close relationships or a factor can include several other factors to describe the information without serious loss. The second method is the grey white weight function cluster, which is applied to judge whether the object belongs to a different classification.

The grey decision is obtained using the grey coefficient combined with the grey model. The effect is calculated using two methods; first: the measure is based on $GM(n,k)$; second: the measure is obtained by extending the relational coefficient. The measure of grey can be optimal or suboptimal situations.

EVALUATION OF STUDENTS MAJORING IN PHYSICAL EDUCATION

Determination of an Evaluation Index System

Measurement of the skills of students is by their performances at practical activities during four years at college. These reflect the physiological qualities and psychological characteristics required by their teaching. Physical skills, at the core of teaching physical activities, develop alongside students' intellectual abilities.

The evaluation index of student skills was obtained by a questionnaire survey, and a literature review. The subjects were 800 college students, from 30 colleges, majoring in physical education. Of the 800 questionnaires issued, 759 were returned, for a response rate of 95%. An extensive literature review was also conducted.

The evaluation index system of student skills is listed in Table 1.

Table 1: Evaluation index system of skills of students majoring in physical education.

First grade indices	Second grade indices
Teaching ability (I1)	Teaching (I11)
	Management of education (I12)
	Being a model for others (I13)
	Moral evaluation (I14)
Physical teaching (I2)	Drawing up teaching documents (I21)
	Teaching organisation (I22)
	Teaching methods (I23)
	Dealing with unexpected events (I24)
	Examinations and evaluations (I25)
Training (I3)	Scientific selection (I31)
	Applying training methods (I32)
	Bench coaching (I33)
	Training evaluation (I34)
Research innovation (I4)	Collecting and presenting information (I41)
	Writing papers (I42)
	Accepting new information (I43)
	Putting forward new insights (I44)
	Independent study (I45)
Social activity (I5)	Organising mass sports activities (I51)
	Refereeing (I52)
	Providing consultation on physical and mental health (I53)
	Evaluating constitution situations (I54)
Mastering and applying tools (I6)	Operating computers (I61)
	Oral expression (I62)
	Foreign language (I63)
	Operating electronic instruments (I64)

Referenced and Comparative Series

The evaluation values of second grade indices for *i*-th first grade indices lead to the following vector [7]:

$$V_i = (V_{1i}, V_{2i}, \cdots, V_{mi}) \tag{7}$$

where V_{ki} denotes the value of *k*-th second grade index for *i*-th first grade index with $k = 1, 2, \cdots, m$, $i = 1, 2, \cdots, n$.

The optimal value $V_{k0} = Best(V_{ki})$ of the *k*-th second grade index is used as the *k*-th weight of the referenced series, and the referenced series is expressed as follows:

$$V_0 = (V_{10}, V_{20}, \cdots, V_{m0}) \tag{8}$$

The matrix of the evaluation system is expressed as follows:

$$V = \begin{bmatrix} V_{11} & V_{12} & \cdots & V_{1n} \\ V_{21} & V_{22} & \cdots & V_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ V_{m1} & V_{m2} & \cdots & V_{mn} \end{bmatrix} \tag{9}$$

In order to unify the dimensions of all the indices, the evaluation indices are normalised as follows [8]:

$$X_{ki} = \frac{\left|V_{ki} - Best(V_{ki})\right|}{\left|Best(V_{ki}) - Poor(V_{ki})\right|} \tag{10}$$

Where $Poor(V_{ki})$ denotes the value of k the *poor* value of the second grade index, and the final evaluation vector is expressed as follows:

$$X_i = (X_{1i}, X_{2i}, \cdots, X_{mi}) \tag{11}$$

Calculation of the Relational Coefficient

The relational coefficient is calculated as the distance between the referenced point and the comparative point for second grade indices. The vector of second grade indices for different first grade indices is normalised to obtain the new referenced series $X_0 = (X_{10}, X_{20}, \cdots, X_{m0})$, and the vector X_i $(i = 1, 2, \cdots, n)$ is the comparative series. The relational coefficient can be calculated as:

$$\lambda \tag{12}$$

where $\lambda = 0.5$ in this research.

According to (12), the relational coefficient matrix is:

$$C = \begin{bmatrix} c_{11} & c_{12} & \cdots & c_{1n} \\ c_{21} & c_{22} & \cdots & c_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ c_{m1} & c_{m2} & \cdots & c_{mn} \end{bmatrix} \tag{13}$$

Data for the k th second degree indices in recent t years for physical education lead to the vector $Z_k = (Z_{k1}, Z_{k2}, \cdots, Z_{kt})$, $k = 1, 2, \cdots, m$. The scores for physical education in the recent t years leads to the vector Z_k. The absolute relational degree between Z_k and Z_0 is calculated according to the following expression:

$$\alpha_{0k} = \frac{1 + |r_0| + |r_i|}{1 + |r_0| + |r_i| + |r_i - r_0|} \tag{14}$$

where r_i is calculated according to:

$$r_i = \sum_{j=1}^{t-1}(Z_{kj} - Z_{k1}) + \frac{1}{2}(Z_{kj} - Z_{k1}),$$

$$i = 0, 1, \cdots, t \quad (15)$$

The relative relational degree between Z_k and Z_0 is calculated according to the following expression:

$$\delta_{0k} = \frac{1 + |r_0^{'}| + |r_i^{'}|}{1 + |r_0^{'}| + |r_i^{'}| + |r_i^{'} - r_0^{'}|} \quad (16)$$

where $r_i^{'}$ is calculated according to the following expression:

$$r_i^{'} = \sum_{j=1}^{t-1}(\frac{Z_{kj}}{Z_{k1}} - 1) + \frac{1}{2}(\frac{Z_{kj}}{Z_{k1}} - 1) \quad (17)$$

The relational degree between Z_k and Z_0 is calculated according to:

$$\mu_{0k} = \xi\alpha_{0k} + (1-\xi)\delta_{0k} \quad (18)$$

where ξ denotes the regulator with $\xi = 0.5$ in this research.

The weight of every second index can be obtained through the relational degree, which is expressed as follows:

$$W = [\omega_1, \omega_2, \cdots, \omega_m] \quad (19)$$

where ω_i is calculated according to the following expression:

$$\omega_i = \frac{\mu_{0i}}{\sum_{i=1}^{m}\mu_{0i}}, \ i = 1, 2, \cdots, m \quad (20)$$

The relational degree of the first degree indices is calculated according to the following expression:

$$R = WC \quad (21)$$

The value of the relational degree for every first grade index indicates the possibility of improvement of the students.

CASE STUDY

The data from 800 college students majoring in PE in 30 colleges were used to carry out an empirical analysis, using the grey system theory. The weights of second degree indices were calculated according to Formula (19), and the results are shown in Table 2.

Table 2: Weight of second grade indices.

Second grade index	Weight	Second grade index	Weight
(I11)	0.21	(I41)	0.09
(I12)	0.25	(I42)	0.23
(I13)	0.23	(I43)	0.22
(I14)	0.31	(I44)	0.11
(I21)	0.17	(I45)	0.35
(I22)	0.22	(I51)	0.14
(I23)	0.14	(I52)	0.42
(I24)	0.21	(I53)	0.23
(I25)	0.26	(I54)	0.21
(I31)	0.24	(I61)	0.15
(I32)	0.21	(I62)	0.32
(I33)	0.32	(I63)	0.14
(I34)	0.23	(I64)	0.39

The relational degree of the first degree indices can be calculated according to Formula (21) and the results are shown in Table 3.

Table 3: Relational degree of first degree indices.

First degree index	Relational degree
I1	0.557
I2	0.643
I3	0.518
I4	0.421
I5	0.446
I6	0.384

The first degree indices are ranked as follows: I2 > I1 > I3 > I5 > I4 > I6. As can be seen from the results, physical teaching is essential in improving the abilities of students majoring in physical education. Therefore, training in physical teaching should be a focal point of the PE course.

Other skills should be developed at the same time, and the evaluation results should offer a theoretical base for training students majoring in PE. This points the way to further reform in teaching PE.

CONCLUSIONS

A qualitative and quantitative analysis, based on the grey system theory, was carried out to evaluate the skills of students majoring in physical education. The evaluation index system was verified, using questionnaire data and the first- and second-degree indices were obtained. The ranking of the indices was evaluated and a teaching reform measurement determined. This provides a mechanism by which to improve the abilities of students majoring in physical education.

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