Research on Comprehensive Evaluation Model of Physical Education Teaching Quality Based on Multivariate Data

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Abstract

Because of the complexity of the factors affecting the quality of teaching has obvious, lead to the larger error in the results of the assessment. Therefore, put forward the physical education teaching quality comprehensive evaluation model based on multivariate data research. Using the analytic hierarchy process (AHP) to build the physical teaching quality evaluation mechanism, based on the relative importance of data, establish compound consistency check of judgment matrix. The weights were assigned according to the importance of the data, and the weighted results were equally divided by the method of pulling apart grades. Finally, the physical education teaching quality was evaluated based on AHP-ISD model. The experimental results show that the accuracy of the method can reach more than 97%, which is obviously better than the method of comparison.

Keywords: multivariate data; physical education teaching quality; comprehensive evaluation; analytic hierarchy process; consistency test; pull class method;

1. Introduction

Published in May 2007, opinions on Strengthening Youth Sports and Enhancing Youth Physique (Document No. 7 of 2007 issued by the general office of the CPC Central Committee, hereinafter referred to as Document No.7 of the Central Committee). The document said, governments at all levels and education departments should attach great importance to school PE work, establish and improve school PE work mechanisms and supervision and monitoring systems; widely carried out "Hundreds of millions of students sunshine sports"; strengthen the construction of school sports facilities and sports safety management, guide teenagers to scientific exercise, etc. (Rukavina et al., 2019; Wassenaar et al., 2019; Michael et al., 2019). The document is put forward to promote the development of youth sports unremittingly through the joint efforts of the whole party and the whole society, and constantly improve the level of youth physical health. A strong youth makes a strong country. It has been nearly fourteen years since the central government issued no. 7 document. So far, the physical health of young people can be said to be both positive and negative. Happily, with the development of the social economy, the height of teenagers has increased, and the incidence of frequently-occurring and common diseases has decreased year by year. It is worrisome that the cardiopulmonary function index of students, one of the most important indicators of health, has been declining for 20 consecutive years, and the proportion of poor eyesight remains high.

For this phenomenon, the Party and the government have always attached great importance to it. For this reason, on October 22, 2012, they forwarded the "Notice of Several Opinions on Further Strengthening School Physical Education Work". The introduction of this document fully reflects the government's high attention to the physical health of teenagers. School physical education should be comprehensively strengthened with primary and secondary schools as the focus (Bessa et al., 2021; Leahy et al., 2019; Asogwa et al., 2020). Carry out PE curriculum and extracurricular sports activities, strengthen the construction of school PE teachers and school PE facilities, and improve the school PE risk management system. Improve students' physical health testing and evaluation system, implement school physical education work evaluation system, implement school physical education report publicity system, strengthen the leadership and management of school physical education, increase the investment in school physical education, implement the three-year action plan of school physical education.

In order to promote the healthy growth of students and realize the overall development of people, we must start with the ultimate goal of physical education, which is to enhance students' physique and improve students' physical health. Sports teaching is a central part of the school sports work. School sports work smoothly and closely around the sports teaching in order to develop, so only to strengthen the assessment of school physical education teaching, get timely feedback information. We should grasp the physical education teaching as the central link and basic way of school physical education, promote construction through evaluation, achieve the goal of physical education, and

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fundamentally solve a series of physical health problems such as the decline of students' cardiopulmonary function and physical quality. According to the learning stage, preschool is the pre-school education stage, childhood is the primary school stage, juvenile is the junior middle school stage, early youth is the high school stage. The age psychological characteristics of each stage, not only there are quantitative differences, but also qualitative differences. Senior middle school (referred to as senior high school) is one of the stages of basic education. It is the last stage for students to directly enter social work or enter higher education. Its importance in the whole educational process is very significant. Therefore, it is particularly important to carry out empirical research on physical education teaching evaluation index system (Cheng et al., 2020; Xu & Rappaport, 2019; Zhu et al., 2020).

Based on this, this paper designed a comprehensive evaluation model of physical education teaching quality based on multivariate data, built the corresponding evaluation mechanism based on the feedback data of physical education teaching quality.

1 Design of comprehensive evaluation model for physical education teaching quality

1.1 Basic principles of PE teaching evaluation model design

In order to adhere to the scientific and feasibility of the evaluation methods, we follow the following principles in the process of developing the evaluation model.

(1) Combining evaluation teaching plan with evaluation teaching practice

The teaching plan is the main basis for teachers to implement teaching contents and arrange teaching methods according to teaching syllabus and teaching plan. Physical education teaching practice is the concrete embodiment of the implementation of teaching syllabus and teaching plan, and is the basic organizational form of physical education. Therefore, in the process of developing an evaluation model, we should start from these two major links, which are both the preparation of evaluation teaching documents and the evaluation teaching process.

(2) The comprehensiveness of evaluation content is combined with the weight of indicators

Physical education teaching evaluation involves both teaching thought and teaching practice. It is a

comprehensive evaluation of teaching elements such as teaching materials, teachers, objects of education and teaching means. At the same time, physical education is different from other professional teaching features in the dynamic space, by physiological, psychological, social, educational and many other factors. Therefore, in the design of evaluation content, both comprehensive and dialectical, reflect the main factors of the teaching task and reflect the overall teaching quality of the pros and cons of the factors as the main evaluation content, while taking into account the various elements of its internal connection. According to their different positions and functions in teaching, determine different weights and scores, fully reflecting the teaching level, so that the evaluation model tends to be reasonable and accurate.

(3) Evaluating the teaching process and teaching effect

Physical education is the unity of teaching and learning, which should play the leading role of teachers as well as the main role of students. Modern physical education teaching should gradually transition from unidirectional teaching to bidirectional or multi - directional teaching. Therefore, the quality of teaching class, not only to evaluate the teacher in the teaching process of all aspects of performance, but so should evaluate the students in the teaching class enthusiasm, initiative, look at the students by education, knowledge and skills, enhance the physical condition. Therefore, due attention should be paid to the teaching effect in the evaluation model.

1.2 Constructing physical education teaching quality evaluation mechanism based on multivariate data

On the basis of the above principles, considering the physical education system is as a unified whole existence so the development of students' intelligence teach master "three bases" enhance students' physique cultivate love for the motherland abide by the discipline and communist moral quality of the process must be coordinated and unified in the physical education system. In this system, teachers should not only pass on physical education knowledge to students through various teaching methods and means, but also follow the teaching rules to control the teaching system overall and achieve a high degree of coordination and unity between teaching and learning through feedback information from students. Teaching process is essentially a process of information transmission if this process is regarded as a complex system, the main factors that constitute this complex system are subsystems such as teachers, students, teaching

materials and teaching methods. As there are many factors affecting teaching quality, this paper takes the effect of multiple data indicators into full consideration when evaluating teaching quality, and takes the multiple data related to physical education teaching quality as the evaluation basis. This directly leads to the relatively complex composition of evaluation data (Verma & Chandra, 2021; Huang et al., 2020; Hang et al., 2020). Therefore, this paper takes it as the basic core to build a physical education teaching quality evaluation mechanism. It is mainly divided into objectives, criteria and programs, etc. The teaching quality evaluation process based on analytic hierarchy process is as follows:

(1) The decision problem is divided into different layers and analyzed according to the order of general objective, sub-objective, criterion layer and scheme layer;

(2) The priority weight of each layer element to the upper layer element is solved, and the solving process is completed by solving the eigenvector method of analysis matrix;

(3) By adopting weighted summation measure, the final weight of each scheme to the overall goal is obtained by recursive merging of priority weights, and the decision scheme with the largest final weight is the final scheme.

The structural mechanism of the overall physical education teaching quality evaluation factors is shown in Figure 1.
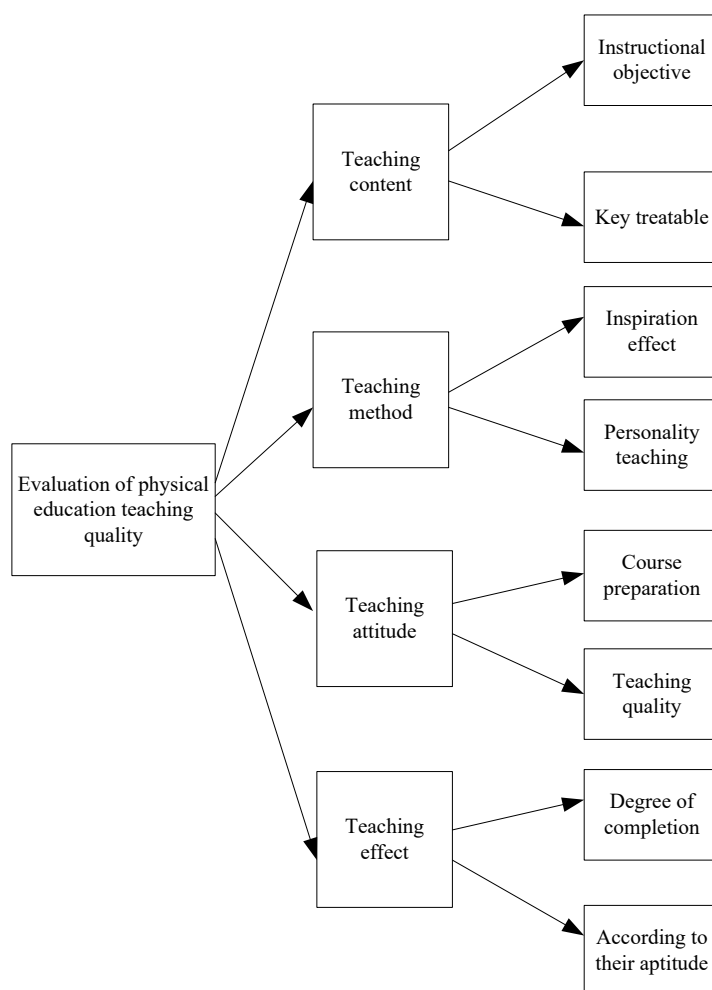

Fig.1 Evaluation mechanism of physical education teaching quality

According to the analytic hierarchy process, the evaluation factors of physical education teaching quality are divided into three target levels. Firstly, there is the general objective layer I, the evaluation layer of physical education teaching quality.

Secondly, according to the general objective layer, it is decomposed into four objective layer II, including teaching content, teaching method, teaching attitude and teaching effect. Finally, the objective layer II is decomposed into objective layer III, including

teaching purpose, considering personality differences and professional dedication, etc. As can be seen from these hierarchical structures, the implementation of each layer has an impact on the evaluation of the next layer (Abdelhadi & Nurunnabi, 2019; Zhang et al., 2020; Peng & Dai, 2019).

The analytic hierarchy process uses 1-9 scale method to calculate the weight of evaluation factors at each level compared with evaluation objectives, that is, to clarify the weight of evaluation factors. The process of AHP to determine the weight is as follows:

(1) Analyze and compare the importance of factors at each layer, and use 1-9 scaling method to create a scaling judgment matrix.

(2) To implement the consistency test, if not passed, to create a scale judgment matrix from scratch.

1.3 Establishing the comprehensive evaluation model of physical education teaching quality

On the basis of the above evaluation mechanism, this paper designs a comprehensive evaluation model of physical education teaching quality based on hierarchical analysis of multivariate data. The specific implementation process is as follows.

1.3.1 Creating a judgment matrix

Setting the number of evaluation factor sets for this layer as m, the evaluation factors are v_1, v_2,…, v_m, using domain experts to compare the relative importance of each factor.

Set d_{ij} to be the importance value of v_i relative to v_j when there is:

$$v_i \text{ compared to } v_j \begin{bmatrix} \textit{As important} \\ \textit{Less important} \\ \textit{Obviously important} \\ \textit{Especially important} \\ \textit{Absolutely vital} \end{bmatrix} \text{(1)}$$

In this case, the corresponding d_{ij} values are respectively:

$$d_{ij} = \begin{bmatrix} 1 \\ 3 \\ 5 \\ 7 \\ 9 \end{bmatrix} \text{(2)}$$

If v_i and v_j are compared between levels, the severity value scales 2, 4, 6,8 are used.

Through formula (1), a weight judgment matrix D is obtained, as shown in formula (3):

$$D = (d_{ij})_{m \times n} \quad d_{ij} = \frac{1}{d_{ij}} \text{(3)}$$

On this basis, it can be used as the basis to evaluate the multivariate data of physical education teaching.

1.3.2 Consistency test

In order to improve the reliability of evaluation results, it is necessary to calculate the maximum eigenvalue of D and take it as the standard of weight division of evaluation group. The calculation method is shown in formula (4):

$$DI = \frac{\alpha_{\max} - m}{m - 1} \text{(4)}$$

In formula(4), $\alpha_{\max}$ represents the maximum eigenvalue of D, and m is the evaluation factor. When DI =0, it indicates absolute consistency. When DI is close to 0, relative consistency exists. Conversely, higher DI indicates lower data consistency.

Therefore, the consistency ratio is defined again, as shown in formula (5):

$$DK = \frac{DI}{KI} < 0.1 \text{(5)}$$

In formula(5), *KI* represents the correlation coefficient between data, and the reference value is (0,0,0.58, 0.9, 1.12, 1.24, 1.32, 1.41, 1.45, 1.48, 1.51).

On the above basis, the corresponding feature vectors $(q_1$, q_2,…, $q_m)$, normalize the feature vector elements to obtain the weight set

$(b_1, \ b_2, \dots b_n)$, as in formula (6):

$$b_i = \frac{q_i}{\sum\limits_{i=1}^{m} q_i}, \quad DK = \frac{DI}{KI} < 0.1$$

(6)

In this way, the characteristics and weights of multivariate data of physical education teaching quality are determined.

1.3.3 Evaluation grade division

Considering that the analytic hierarchy process is prone to the interference of subjective factors, the subjective limitations of evaluators will make the model unable to complete the high-precision evaluation. In order to reduce the overall variation degree of each evaluation factor in all indicators and the interference degree of other evaluation factors, this paper improved the Improved Scatter Degree (ISD) (Hasannasab et al., 2021; Jin, Mesiar, & Yager, 2019; Sun et al., 2020). Based on the solved weight coefficient and the objective origin of information, the evaluation targets were divided into different levels, achieve the division of evaluation grades. The ISD algorithm process is as follows.

(1) Read original data $A_{m \times n}$, data from m rows and n columns;

(2) Multiply each column of data in $A_{m \times n}$ by the weight coefficient obtained by the corresponding Analytic Hierarchy Process (AHP) to obtain $A*_{m \times n}$;

(3) Set $R = A*^T A*$, calculate the eigenvalue C and eigenvector U of R , and calculate the

corresponding eigenvector U_{max} of the maximum eigenvalue C_{max} ;

(4) Calculate the weight b_j , as shown in formula (7).

$$b_j = \frac{U_{max\,j}}{\sum\limits_{i=1}^{m} U_{max\,j}}$$

(7)

In formula (7), the number of multivariate data describing evaluation is $j=1,2,3,\dots,m$.

AHP and ISD weighting method are used to calculate the comprehensive weight of evaluation factors to improve the accuracy of the weight of physical education teaching quality evaluation factors, and the weight of the comprehensive integrated assignment method is shown in equation (8).

$$b = e_1 b_i + e_2 b_j,$$
$$s.t. \ e_1 + e_2 = 1, \ e_1 > 0, \ e_2 > 0$$

(8)

In formula(8), b represents the comprehensive weight of evaluation factors, and b_i and b_j represent the weight of AHP and ISD.

According to the above calculation results, the final weight synthesis results of multivariate data are shown in Table 1.

Table 1

Synthesis results of multivariate data weights

A single weight	Teaching method	Students	Teachers	Teaching material
Teaching objectives	0.3477			
The key to deal with	0.2627			
Inspired by the effect of		0.3333		
Individuality teaching		0.2500		
Courses to prepare			0.4167	
The quality of teaching			0.3692	
To complete the degree				0.2850
According to their aptitude				0.1922

On this basis, the grade of teaching quality assessment is divided, and the specific results are shown in Table 2.

Table 2

Grade division results of teaching quality assessment

Comprehensive weight results of multivariate data	Assessment level	Level description
1.0-0.8	1	Excellent teaching quality
0.8-0.6	2	Good teaching quality
0.6-0.4	3	Teaching quality is average
0.4-0.2	4	The quality of teaching is poor
0.2-0.0	5	The quality of teaching is abysmal

The partitioning results in table 2 are used as the final model output standard.

1.3.4 Constructing teaching quality evaluation model

On the basis of the above, firstly, the weight b_i of AHP is calculated by normalization of each evaluation factor, and the weight b_j of ISD is calculated by the improved open grade method. Thirdly, the comprehensive weight b of evaluation factors is calculated by using AHP and ISD weighting method to achieve the comprehensive integrated weight assignment. Improve the correct rate of weight of evaluation factors of physical education teaching quality. In combination with the above results, a physical education teaching quality assessment model S based on AHP-ISD is constructed, as shown in formula (9):

$$S = \sum_{i=1}^{m} bK_m \quad (9)$$

In formula, K_m represents the evaluation value of evaluation factors, and the evaluation level of physical education teaching quality can be obtained through the above formula.

1.3.5 Model validation

The evaluation factor data is divided into training set and sample set, and the bayesian classifier is created through the training set data. According to the test set data, the evaluation accuracy of AHP-ISD teaching quality evaluation model is tested.

Bayesian classifier uses Bayesian formula, as shown in formula (10).

$$F(G|X) = \frac{F(G|X) * F(G)}{F(X)} \quad (10)$$

$F(G|X)$ under the condition of X posterior probability G; $F(G)$ represents the prior probability of G. $F(G|X)$ represents under the condition of G posterior probability X, the prior probability of $F(X)$.

Training I was divided into feature vector q and decision category variable G by Naive Bayes Classifier (Abbreviated as NB-classifier) (Marcos de Moraes, Soares, & Machado, 2020; Ray, Chouhan, & Verma, 2020).

In actual use, reducing the complexity of creating bayesian networks is accomplished by reducing the exponential level. In addition, naive Bayes still shows certain efficiency and power even when this assumption is violated in many fields. Therefore, this paper adopts this method to verify the model.

For the convenience of description, H and Z represent category variables and attribute variables respectively, assuming that there are n attribute variables $Z = \langle Z_1, Z_2, \ldots, Z_n \rangle$, the range of category variable and attribute variable is $Val(H) = \{h_1, h_2, \ldots, h_l \rangle$, $Val(Z_i) = \{z_{i1}, z_{i2}, \ldots, z_{ik}\}$ represents z_i and some value of Z_i. X represents the set of samples to be divided, and $x = \langle z_1, z_2, \ldots, z_m \rangle$ represents the sample to be divided, Y represents the training sample set, $y_i = \langle z_1, z_2, \ldots, z_n, hi \rangle$ represents training data. Assume that each property and categories are independent of each other, the $F(h_i|x)$ can be decomposed into several components: the product of $F(h_1|z_1) * F(h_i|z_2) * \ldots * F(h_i|z_n)$, so the posterior probability calculation formula is obtained, as shown in formula (11).

$$F\left(h_i \mid x\right) = \frac{F(h_i)}{F(x)} \prod_{i=1}^{n} F\left(z_i \mid h_i\right)$$

(11)

According to the a posteriori probability $F\left(h_i \mid x\right)$ the biggest category of complete bayesian classifier evaluation, the detailed process is as follows.

(1) Data preprocessing: attribute $Z = \langle Z_1, \ Z_2, \ldots, \ Z_n \rangle$ implements characteristic reduction;

(2) Judgment: If the classified task, then transfer to process (5), if the training task to process (3);

(3) the parameter learning: scan all samples calculated all the prior probability of $F\left(h_{ik} \mid h_j\right)$, h_i is category, properties of z_i, is the first k values of probability, and $F\left(h_j\right)$, which is the category of h_j probability values;

(4) Generate the Bayesian probability table, that is, the desired Bayesian classifier;

(5) Call the Bayes classification table to obtain the classification results. If the classification is ideal, it indicates the reliability of the model's classification results.

2 Application research

2.1 The research object

53 PE teachers from 9 senior middle schools in 3 districts of a city were investigated, and the physical health of 12676 students was analyzed. According to data requirements, I read and learned a large number of books and materials related to questionnaire survey and scientific research before designing the questionnaire, laying a sufficient theoretical foundation for the design of the questionnaire. According to this study and purpose and in close combination with "the central 7 file", "the State Council document no. 53" and "2020 education development plan outline" of the spirit of the three files, designed a model based on the model of multivariate data required for evaluation of school leaders and the PE teacher questionnaire, and through the expert questionnaire for the validity of the test. The questionnaire was distributed to 6 experts engaged in physical education, including 5 professors and 1 associate professor. Through the weight assignment and selection of the subject content of the questionnaire, its content finally meets the requirements.

2.2 The data collection

Fifty-three questionnaires were sent out and fifty were recovered, with a recovery rate of 94.3% and an effective rate of 100%. 9 leadership questionnaires were sent out with the recovery rate of 100% and the effective rate of 100%. The general mathematical statistics method is adopted and excel software is used to conduct statistical processing on the data obtained from the questionnaire survey, and the results are shown in Table 3.

Table 3

Statistical table of survey result scoring data

The data type	Municipal key	District key middle school	Ordinary high school
Teaching objectives	8.51	7.66	7.12
The key to deal with	7.77	7.16	7.36
Inspiration effect	8.13	7.92	7.46
Personality teaching	9.26	8.90	8.17
Course preparation	9.11	8.59	8.42
Teaching quality	9.35	8.90	8.58
Degree of completion	9.24	8.46	7.98
According to their aptitude	8.46	7.22	7.07

The evaluation results are conducted on a 10-point scale. Based on this, the model designed in this paper and the evaluation methods proposed in literature is used to test, and the evaluation effects of the three methods are analyzed by comparing with the actual teaching quality.

2.3 Analysis of evaluation Results

On the basis of the above, in order to improve the objectivity of the evaluation results evaluation, this paper respectively by lung capacity weight index (the ratio of the body's own vital capacity and weight, the relative value of vital capacity per kilogram of body weight to reflect the relevance of the vital capacity and weight) grade pass rate as a quantitative index, to evaluate the results of comparative analysis.

2.3.1 The results of physical education teaching evaluation in key middle schools of the city

The evaluation results of the three methods for

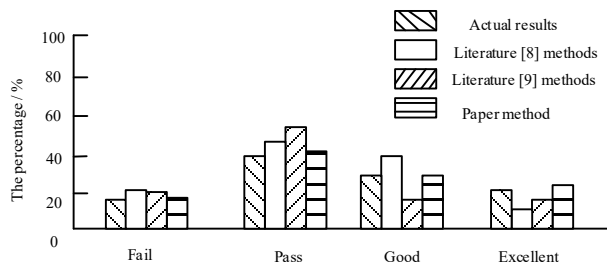students in municipal key middle schools are shown in Figure 2.

Fig.2 Comparison of PE teaching evaluation results of municipal key middle schools

As can be seen from figure 2, the evaluation results of literature (Xu, D., & Rappaport, T. S. 2019) and literature (Xu, D., & Rappaport, T. S. 2019) on vital mass index pass rate of municipal key middle schools have obvious errors. And the estimation deviation of good rate is also significantly higher than that of the design method in this paper. Across the four levels of evaluation results, the method and the fit of the actual vital capacity of body mass index scores remain at a high position, not only that, the influence of the position of key middle school, in the exercise of non-sports teaching stage, there exist certain differences which is lead to the vital capacity, the main reasons for the higher average body mass index method achieved good evaluation results, this paper It is also because in the evaluation process, the processing of basic data is more reasonable, and the weighting results of corresponding data are more scientific.

2.3.2 Evaluation results of PE teaching in key middle schools of district

The evaluation results of the three methods for key middle school students in the district are shown in Figure 3.
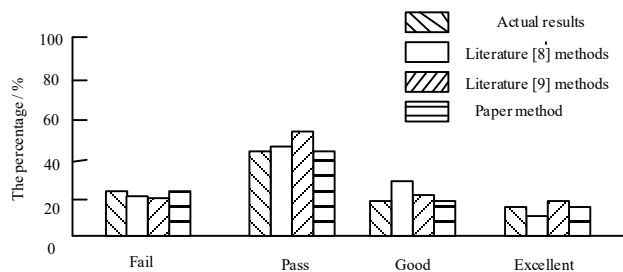

Fig.3 Comparison of PE teaching evaluation results of district key middle schools

It can be seen from the figure 3, the literature (Xu, D., & Rappaport, T. S. 2019) and literature (Xu, D., & Rappaport, T. S. 2019) evaluation results, the index of lung capacity weight grades for good error probability estimates, by contrast, in this paper, the model for each stage of design performance evaluation results consistently maintaining high accuracy, especially for passing probability estimates, and the error of the

actual results achieved 1.0%. It also shows that the model designed in this paper has a good application effect in physical education teaching quality evaluation.

2.3.3 Evaluation results of PE teaching in ordinary middle schools

The evaluation results of the three methods for ordinary middle school students are shown in Figure 4.
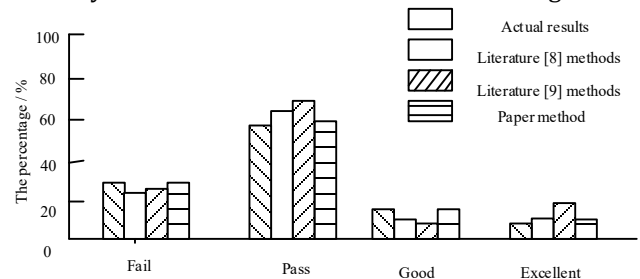

Fig.4 Comparison of physical education teaching evaluation results in ordinary middle schools

It can be seen from the figure 4, the literature [8] and literature (Xu, D., & Rappaport, T. S. 2019) evaluation results of the method are highly appearing the error, especially for the pass and good probability estimation results, error even reached 10%. The application of physical education teaching quality assessment, easy to cause the wrong evaluation results, influence of physical education teaching reform smoothly. In contrast, the error is always within 3%. Based on the analysis results of the first two universities, it is not difficult to see that the model designed in this paper has a high reliability for the evaluation of physical education teaching quality.

The errors of the three methods are statistically analyzed, and the results are shown in Table 4.

Table 4
Statistical table of evaluation errors of different methods /%

Methods	The maximum	The minimum	The mean
Methods of literature [8]	10.22	3.31	5.22
Methods of literature [9]	11.24	2.91	5.91
Paper method	2.96	0.72	1.26

As can be seen from table 4, the maximum error, minimum error and mean value of the evaluation results of this method are significantly better than those of the other two comparison methods.

3 Conclusions

In this paper, analytic hierarchy process and the improved open grade method are used to design a comprehensive evaluation model for calculation, in order to obtain the weight of physical education teaching quality evaluation and comprehensive

assigned weight, can make the accuracy of the weight of physical education teaching quality evaluation factors get improved. On the basis of the weight of the comprehensive assignment, bayesian classifier was used to construct a bayesian teaching quality evaluation model based on AHP-ISD to comprehensively evaluate the quality of physical education. The model of this paper not only improves the accuracy of PE teaching quality comprehensive evaluation, but also provides a basis for other teaching quality comprehensive evaluation.

In future studies, the severity points can be optimized from the following aspects:

(1) To some extent, the degree of attention colleges attach to physical education also affects the quality of physical education. Therefore, relevant indicators, such as the frequency of course setting and the quantity of sports equipment purchase, can be included in the evaluation;

(2) For the weight assignment results, the actual teaching data should be constantly used to optimize, to improve the accuracy of the evaluation results;

(3) Teaching quality is a relatively broad indicator, and the reliability of evaluation results can be improved by concretizing evaluation indicators.   .

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