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Professional Development and Psychological Adjustment of Physical Education Teachers

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Abstract
The professional development of physical education (PE) teachers is the core of cultivating professional PE experts with excellent instructiveness and pedagogical quality. The existing studies on the professional development of PE teachers (PETPD) mainly focus on the specific development strategies, and the correlation between professional development and education reform, failing to consider the psychological factors that affect PETPD. Therefore, this paper explores deep into PETPD, and its correlation with psychological adjustment ability (PAA). Specifically, the PETPD model was given, and an evaluation index system (EIS) of PETPD was constructed, in the light of the psychological adaptation of PE teachers. Next, a comprehensive PETPD evaluation model was established based on entropy weight - technique for order of preference by similarity to ideal solution (TOPSIS), and PETPD prediction was detailed based on deep neural network (DNN). Through experiments, the comprehensive evaluation results on PETPD were subjected to multiway analysis of variance (ANOVA), and the influence of different factors on the PAA of primary school PE teachers was discussed under the demand of professional development. The research results prove the important positive effect of professional development and psychological adjustment on the career development of PE teachers.
Keywords: physical education (PE) teachers; professional development; psychological adjustment ability (PAA); technique for order of preference by similarity to ideal solution (TOPSIS)

1. Introduction

Concerning the professional development of physical education (PE) teachers (PETPD), disciplinarity, academic quality, instructiveness, and pedagogical quality are among the various factors that affect the training of professional PE experts with excellent instructiveness and pedagogical quality (Almusawi et al., 2021; Castro-Maqueda et al., 2019; Choresh & Hutzler, 2020; Cruz et al., 2021; Franuszkiewicz et al., 2019; Lee et al., 2020; Li, 2021; Liu & Liao, 2020; Muhtar et al., 2020). PETPD is an innovation of the PE model and teacher management system. One of the key issues in PETPD is to construct a reasonable theoretical interpretation framework and development model for PETPD, improve PE teachers' psychological adjustment ability (PAA), and promote the rapid growth of PE teachers (Cheng, 2017; Fan, 2015; Fitri et al., 2021; Jauhariyah et al., 2019; Klochko et al., 2020; Nantsou et al., 2021; Suyatna, 2019; Xiaozhi et al., 2015).

Most domestic research of PETPD are discipline-specific, focusing on pre-employment training, i.e., adopting traditional one-time cultivation model. As a result, the PETPD research in China remains in the infancy stage. Exploring the evaluation methods of PE teachers' comprehensive quality helps to promote their professional development. The PETPD ultimately hinges on the teachers' understanding and execution. To further advance the professional development of PE teachers, it is significant to study the psychological adaptation of PE teachers to their professional development, understand how well they adapt to the changes in professional development, and deeply analyze the various factors affecting PETPD.

Domestic and foreign scholars have conducted practical research into the sustained professional development of teachers in different majors. Hongyim and Brunsell (2021) studied the impacts of professional teacher development by a series of scientific teaching methods, identified or created phenomena and events, and applied them in class to improve student learning. Ramanan (2021) verified a practical tool for the sustained professional development of teachers, evaluated the ability of teachers to become high-quality educators, and divided the tool into five dimensions of TCPD and seven dimensions of teacher ability through confirmatory factor analysis (CFA). The results imply the importance of professional teacher development, which plays a critical role in student growth. Kholis et al. (2021) expounded on the paths to high education quality and teacher development training in vocational schools, and proposed multiple measures for planning and implementing effective training plans: determining demand, setting goals, identifying learning contents, selecting participants, optimizing timetable, choosing the right facilities, and arranging suitable lecturers. Fu (2020)

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examined the performance appraisal of undergraduate program teachers with backpropagation neural network (BPNN), and guided professional teacher development with a brand-new evaluation method. Based on sports construction theory, Yevtuch et al. (2021) applied virtual reality (VR) to improve the health care ability of PE teachers, and experimentally proved that the virtual model can effectively enhance the said ability of PE teachers.

PETPD is the requirement of PE curriculum reform, the pedagogical education of PE teachers, and the quality improvement of PE teachers. However, the existing studies on PETPD mainly focus on the specific development strategies, and the correlation between professional development and education reform, failing to consider the psychological factors that affect PETPD. Most of domestic studies on teachers' psychological adjustment emphasizes on a group of people, trying to establish and verify universal theories. The few application researches focus on giving macro-level instructions in specific fields like psychology and education. There is little report on a specific group in a particular environment. Therefore, this paper explores deep into PETPD, and its correlation with PAA. Section 2 clarifies the structure of PETPD model, and sets up an evaluation index system (EIS) of PETPD, in the light of the psychological adaptation of PE teachers. Section 3 establishes a comprehensive PETPD evaluation model based on entropy weight - technique for order of preference by similarity to ideal solution (TOPSIS). Section 4 details the PETPD prediction based on deep neural network (DNN). Finally, the comprehensive evaluation results on PETPD were subjected to multiway analysis of variance (ANOVA), and the influence of different factors on the PAA of primary school PE teachers was discussed under the demand of professional development.

This research formulates a reasonable model and EIS for PETPD, and solves the basic theoretical problems in PETPD. The practical significance is that the proposed PETPD model, as well as the disclosed effects of psychological adjustment on PETPD, promote the rapid growth of PE teachers, effectively enhance their overall quality, and ensure that the education of PE teachers is in line with China's education demand.

2. PETPD Model and EIS

At present, China's PETPD is still in the preliminary stage: the development speed is slowed down by multiple factors like PE teachers' teaching ability, education level, and PAA, as well as the stability of the faculty. There are mainly three problems in China's PETPD: the incorrect cognition of professionality, the incoherence of PE teacher education system, and the lack of initiative among PE teachers. PETPD face five inevitable trends, which are the core targets of PE teacher education: improving the education level of PE teachers, forging an open training structure of PE teachers, building a teaching team of PE experts, standardizing the certification of PE teachers, and realizing the autonomy of professional PE teachers.

Figure 1 shows the structure of our PETPD model. Referring to the planning for PETPD, the key factors of PETPD model were determined as goals, philosophy, phases, requirements, paths, and indices. Table 1 divides PETPD to four phases, and explains the task of each phase.

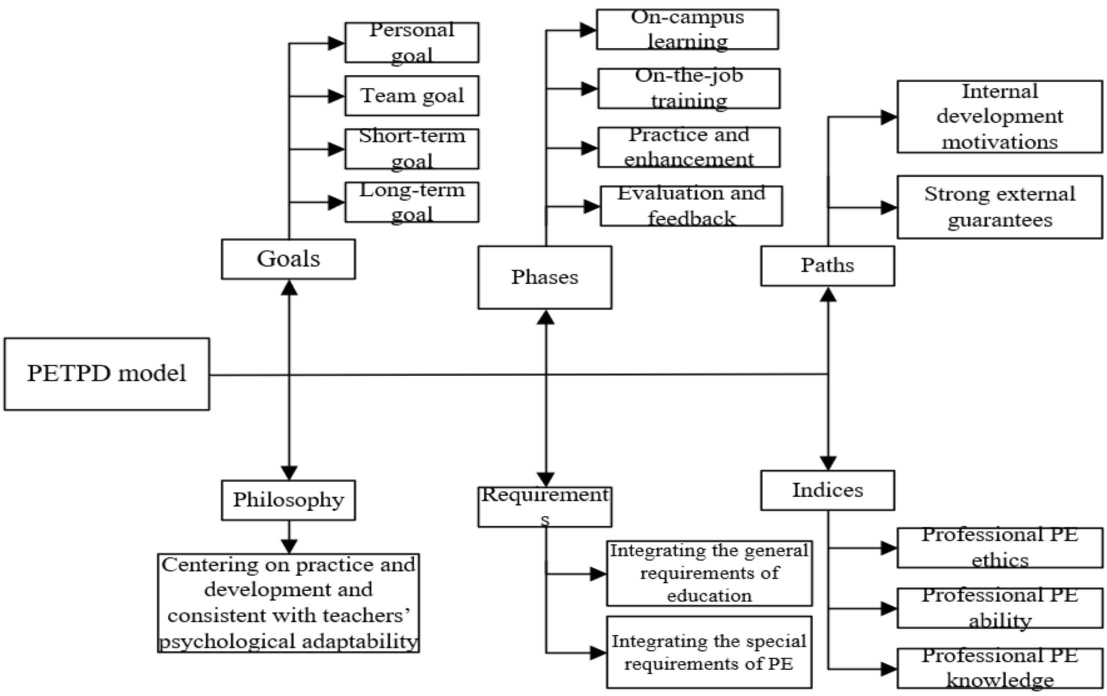

Figure 1. Structure of PETPD model

Table 1

Four phases of PETPD

Phase	Task
On-campus learning	Master the basic knowledge and skills of general courses, PE teaching, and PE
On-the-job training	Integrate PE theories with teaching practice, and gradually develop into professional PE teachers
Practice and enhancement	Advance PETPD against constraints like education level, teaching ability, etc., in line with the mission of PE teachers
Evaluation and feedback	Reach a high level of PE teaching, guide young PE teachers, and initiate the virtuous cycle of PETPD

The psychological adaptation of PE teachers generally refers to the dynamic response of PE teachers via autonomous psychological regulation to meet the changing PETPD demands of the school, such that their teaching attitude, goals, and model better fit in with the new working environment and personal development, and their professional development level reaches a balance with the working environment.

This paper tries to evaluate PETPD in view of the psychological adaptation of PE teachers, and establishes a hierarchical comprehensive EIS of three primary indices and multiple secondary and tertiary indices. The EIS is objective, scientific, and complete.

Layer 1 (primary indices)

PD={PD_1, PD_2, PD_3}={professional PE knowledge, professional PE ability, professional PE ethics};

Layer 2 (secondary indices)

PD_1={PD_{11}, PD_{12}, PD_{13}}={cultural knowledge of general curriculum, knowledge of PE teaching, knowledge of PE};

PD_2={PD_{21}, PD_{22}}={PE teaching ability, PE research ability};

PD_3={PD_{31}, PD_{32}}={PE spirit, PE teacher ethics};

Layer 3 (tertiary indices)

PD_{11}={PD_{111}, PD_{112}, PD_{113}, PD_{114}, PD_{115}, PD_{116}, PD_{117}}={cultural knowledge of math and natural science, cultural knowledge of social sciences, cultural knowledge of computer, cultural knowledge of languages, cultural knowledge of arts, cultural knowledge of skills};

PD_{12}={PD_{121}, PD_{122}, PD_{123}, PD_{124}, PD_{125}, PD_{126}}={basic knowledge of psychology, basic knowledge of educational psychology, PE curriculum and pedagogy, knowledge of PE psychology, basic knowledge of educational research methods, basic knowledge of modern educational technology};

PD_{13}={PD_{131}, PD_{132}, PD_{133}, PD_{134}, PD_{135}}={ knowledge of human anatomy, knowledge of exercise physiology, knowledge of sports psychology, knowledge of PE, knowledge of sports training and competition};

PD_{21}={PD_{211}, PD_{212}, PD_{213}, PD_{214}, PD_{215}, PD_{216}}={teaching organization ability, language expression ability, teaching design ability, sports skill demonstration ability, education work ability, sports activity instruction ability};

PD_{22}={PD_{221}, PD_{222}, PD_{223}, PD_{224}, PD_{225}}={ scientific paper writing ability, autonomous learning ability, analysis and judgment ability, research project development and completion ability, research results conversion ability};

PD_{31}={PD_{311}, PD_{312}, PD_{313}, PD_{314}}={sports appearance, sports style, sports mentality, sports expectation};

PD_{32}={PD_{321}, PD_{322}, PD_{323}, PD_{324}, PD_{325}, PD_{326}}={professional ideal, professional responsibility, professional attitude, professional disciplines, professional skills, professional conscience, professional style, professional honor}.

3. Comprehensive Evaluation Model

3.1 Principle of entropy weight method

This paper assigns a weight to each index in the PETPD EIS:

Step 1. Data normalization

Suppose a total of l indices were given for PETPD evaluation: PD_1, PD_2, …, PD_l, where PD_i={pd_1, pd_2, …, pd_m}. The normalized indices can be expressed as B_1, B_2, …, B_l. Then, we have:

$$B_{ij} = \frac{pd_{ij} - Min(pd_i)}{Max(pd_i) - Min(pd_i)} \quad (1)$$

Step 2. Following the definition of information entropy in the theory of information, the information entropy of each index can be solved by:

$$IE_j = -ln(m)^{-1} \sum^m o_{ij} ln o_{ij} \quad (2)$$

where, $o_{ij}=B_{ij}/m$. Then, we have:

$$\lim_{o_{ij}\to 0} o_{ij}\, ln o_{ij} = 0 \quad (3)$$

Step 3. Based on the information entropies IE_1, IE_2, …, IE_l of the indices, the weight of each index can be calculated by:

$$\omega_i = \frac{1-IE_i}{l-\sum IE_i} \quad (4)$$

3.2 Evaluation based on entropy weight – TOPSIS

For a PETPD evaluation problem of n PE teachers and m indices, the score of PE teacher i on index j is recorded as U. Then, an initial matrix can be established as $U=(u_{ij})_{n\times m}$. Following entropy weight -TOPSIS, PETPD can be evaluated in the following steps:

The first step is to normalize the original index data. All the indices in PETPD EIS are positive: the greater the index, the better the PE teacher develops in that dimension. Besides, different indices represent different evaluation angles and have different physical meanings. That is, the dimensional difference of indices makes it impossible to make a direct, comprehensive evaluation of things. To solve the problem, the dimensional difference of the indices should be eliminated by:

$$pd_{ij} = \frac{u_{ij} - \underset{i=1,2,\dots n}{Min} u_{ij}}{\underset{i=1,2,\dots n}{Max} u_{ij} - \underset{i=1,2,\dots n}{Min} u_{ij}} \quad (5)$$

where, u_{ij} is the score of PE teacher i on index j; a_{ij} is the normalized score of PE teacher i on index j. The normalized matrix can be described by $PD=(pd_{ij})_{n\times m}$.

Next is to compute the objective weight of each index by entropy weight method. In the initial matrix $U=(u_{ij})_{n\times m}$, the degree of variation for score u_{ij} is positively correlated with the information entropy of the information contained in the corresponding index. Therefore, the greater the variation, the higher the weight of that index.

Step 1. Compute the proportion of the normalized value of each index, i.e., convert the normalized score of each index in normalized matrix $PD=(pd_{ij})_{n\times m}$ into proportion. The contribution o_{ij} of index j to PE teacher i can be calculated by:

$$o_{ij} = \frac{pd_{ij}}{\sum_{i=1}^{n} pd_{ij}} \quad (6)$$

Step 2. The entropy value δ_j of each index can be calculated by:

$$\delta_j = -\frac{1}{lnm}\sum_{i=1}^{n} o_{ij}\, lno_{ij} \quad (7)$$

If $o_{ij}=0$, then $o_{ij}lno_{ij}=0$.

Step 3. The entropy weight γ_j of each index can be calculated by:

$$\gamma_j = \frac{1-\delta_j}{m-\sum_{j=1}^{m}\delta_i} \quad (8)$$

Step 4. The composite score of PETPD, which fully and accurately measures the relative importance between indices, can be calculated by:

$$OR_i = \sum^{n} \gamma_i \cdot o_{ij} \quad (9)$$

Finally, TOPSIS was performed to make the comprehensive evaluation of PETPD.

Step 1. Construct a weighted decision matrix based on the normalized index data. This matrix $B=(u_{ij})_{n\times m}$ can be obtained by multiplying the normalized matrix $PD=(pd_{ij})_{n\times m}$ with index weight vector $\gamma_j=(\gamma_1, \gamma_2, \dots, \gamma_m)$:

$$B = (b_{ij})_{n\times m} = (\gamma_j a_{ij})_{n\times m} \quad (10)$$

Step 2. Determine the positive and negative ideal solutions of the EIS. Simulate the scores of each PE teacher, and define the optimal solution as the ideal solution C^O, in which the score of each index is the optimal value of the index in the decision matrix:

$$C^O(b_1^O, b_2^O, \dots, b_j^O, \dots, b_m^O) = \left(\underset{i=1,2,\dots,n}{max} b_{ij} | j \in J\right) \quad (11)$$

Define the worst solution as the negative ideal solution C^W, in which the score of each index is the worst value of the index in the decision matrix:

$$C^W(b_1^W, b_2^W, \dots, b_j^W, \dots, b_m^W) = \left(\underset{i=1,2,\dots,n}{max} b_{ij} | j \in J\right) \quad (12)$$

Step 3. Compute the Euclidean distances R^O_i and R^W_i from the normalized vector of each index for each PE teacher to the optimal and worst solutions:

$$R_i^O = \sqrt{\sum_{i=1}^{m}\left(b_{ij} - b_j^O\right)^2} \quad (13)$$

$$R_i^W = \sqrt{\sum_{i=1}^{m}\left(b_{ij} - b_j^W\right)^2} \quad (14)$$

Step 5. Compute the relative proximity PRO_i of composite PETPD score to the ideal solution C^O:

$$PRO_i = \frac{R_i^W}{(R_i^O + R_i^W)} \quad (15)$$

where, PRO_i is positively correlated with the level of PETPD.

4. DNN-Based PETPD Prediction

By virtue of their strong processing capability of nonlinear adaptive information, the artificial neural networks (ANNs) have been successfully applied to expert system, image processing, pattern recognition, combinatory optimization, and risk prediction. This paper derives a DNN from BPNN, and relies on the DNN to forecast the PETPD, in the light of PE teachers' psychological adaptation. Figure 2 presents the structure of the DNN.

The core principles of the proposed neural network prediction algorithm include forward propagation of signals and backpropagation of error. During network training, the weights and thresholds are updated continuously until the error between the output and the expected value is sufficiently small.

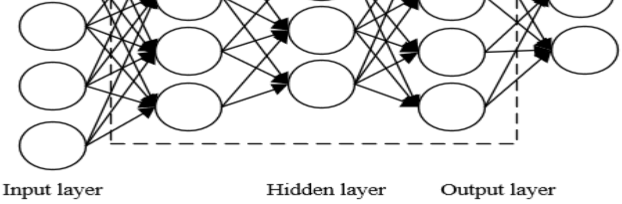

Figure 2. Structure of the DNN

During signal forward propagation, the input PETPD sample of the network can be expressed as:

$$PD_N^n = a(l) \quad (16)$$

According to the connection weight θ_{ni} and threshold γ_i between the input layer and the hidden layer, the input of each hidden layer node can be calculated by:

$$PD_K^i(l) = \sum_{n=1}^{n=N}(\theta_{ni}(l)PD_N^n(l) + \varepsilon_i) \quad (17)$$

After the processing by the hidden layer activation function $g(a)$, the hidden layer output can be obtained by:

$$P_K^i(l) = g\left(PD_K^i(l)\right) \quad (18)$$

According to the connection weight θ_{ij} and threshold γ_j between the hidden layer and the output layer, the input of the output layer can be calculated by:

$$PD_j^i(l) = \sum\left(\theta_{ij}(l)P_K^i(l) + \varepsilon_j\right) \quad (19)$$

After the processing by the output layer activation function $h(a)$, the output of the output layer can be obtained by:

$$P_j^i(l) = h\left(PD_j^j(l)\right) \quad (20)$$

The error between the output and the expected value can be calculated by:

$$error_j(l) = b_j - P_j^i(l) \quad (21)$$

The total prediction error of the network can be calculated by:

$$error(l) = \frac{1}{2}\sum_{j=1}^{J} error_j(l)^2 \quad (22)$$

During error backpropagation, the network weights are adjusted by gradient descent algorithm, which aims to minimize the value of function.

The connection weight θ_{ij} between the output layer and hidden layer can be updated by:

$$\Delta\theta_{ij}(l) = -\lambda\frac{\partial error(l)}{\partial\theta_{ij}(l)} = -\lambda\frac{\partial error(l)}{\partial b_j} \bullet \frac{\partial b_j}{\partial\theta_{ij}(l)} \quad (23)$$

$$\theta_{ij}(l+1) = \theta_{ij} + \Delta\theta_{ij} \quad (24)$$

The partial derivative of the prediction error relative to network output can be obtained by:

$$\frac{\partial error(l)}{\partial b_j} = \frac{1}{2} \bullet \frac{\partial\left(b_j - P_j^j(l)\right)}{\partial b_j} = b_j - P_j^j(l) \quad (25)$$

The partial derivative of the network output relative to the connection weight θ_{ij} can be obtained by:

$$\frac{\partial b_j}{\partial\theta_{ij}(l)} = \frac{\partial h\left(\sum_{j=1}^{J}\theta_{ij}(l)P_K^j(l) + \gamma_j\right)}{\partial\theta_{ij}(l)} = h' \cdot P_K^j(l) \quad (26)$$

Similarly, the connection weight θ_{ni} between the hidden layer and the input can be updated by:

$$\Delta\theta_{ni} = -\lambda\frac{\partial error(l)}{\partial\theta_{ni}} = -\lambda\frac{\partial error(l)}{\partial b_j} \cdot \frac{\partial b_j}{\partial P_K^i(l)} \cdot \frac{\partial P_K^i(l)}{\partial\theta_{ni}(l)} \quad (27)$$

$$\theta_{ni}(l+1) = \theta_{ni}(l) + \Delta\theta_{ni}(l) \quad (28)$$

Let λ be the learning rate. Neural networks can commonly be activated by sigmoid function, tanh function, and rectified linear unit (ReLU) function. The S-type sigmoid function is the most popular activation function:

$$Sigmoid(a) = \frac{1}{1+e^{-a}} \quad (29)$$

The sigmoid function can compress the node input in the real number domain to the interval (0, 1). The smaller the node input, the closer the function output is to zero. The closer the node input is to -∞, the closer the function output is to -1. The closer the node input is to +∞, the closer the function output is to 1. In other words, when the node input approaches 0, the sigmoid function stimulates the input; when the node input approximates ±∞, the sigmoid function suppresses the input. The action mechanism is the same as that of biological neurons.

The tanh function can be defined as:

$$tanh(a) = \frac{e^a - e^{-a}}{e^a + e^{-a}} = 2 \cdot sigmoid(2a) - 1 \quad (30)$$

The tanh function, which has a similar trend as the sigmoid function, also faces the problem of vanishing gradients. The different between them is that the tanh function is an odd function, capable of compressing the node input in the real number domain to the interval (-1, 1). The tanh function is steeper than the sigmoid function, and can reduce the number of iterations.

The ReLU is frequently adopted for DNN training. To a certain extent, ReLU function overcomes the problem of vanishing gradients faced by the previous two functions:

$$ReLu(a) = \begin{cases} a, a \geq 0 \\ 0, a < 0 \end{cases} \quad (31)$$

The ReLU function has several features that can be biologically interpreted, such as a wide excitable boundary and unilateral inhibition. Taking ReLU as the activation function, the DNN can achieve a simpler training and more efficient calculation.

5. Experiments and Results Analysis

A total of 140 primary school PE teachers were selected from four districts of Yancheng, eastern China's Jiangsu Province to receive a questionnaire survey on professional development. The 140 replies were subjected to multiway ANOVA on SPSS. The influence of different factors on these teachers' PAA was explored, in the light of the demands for professional development of primary school PE teachers.

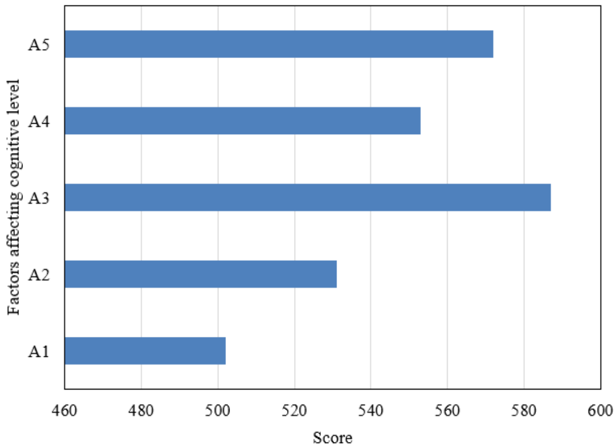

Figure 3. PE teachers' cognition of professional development

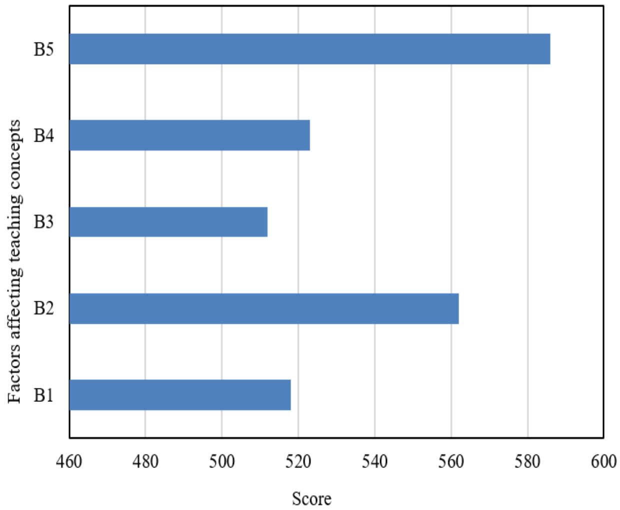

Figure 4. PE teachers' adaptability to teaching concepts

The PE teachers' cognition of professional development was measured by the composite scores of five factors: cognitive level of professional development standards A1, the degree of satisfaction with his/her own education level after professional development A2, the degree of support for the school's professional development demands A3, the positive effect on his/her own teaching A4, and the enhanced learning enthusiasm of PE students A5. As shown in Figure 3, the highest and lowest scores belong to A3 and A1, respectively. This means most primary school PE teachers are positive towards professional development, but do not have an updated cognition of the relevant indices and standards.

In the process of professional development, the adaptability of primary school PE teachers to teaching concepts was measured by the composite scores of five factors: teaching goals B1, teaching methods B2, teacher-student relationship B3, professional ideal B4, and lifelong learning outlook B5. As shown in Figure 4, B5 achieved the highest composite score, followed in turn by B2, B1, B4, and B3.

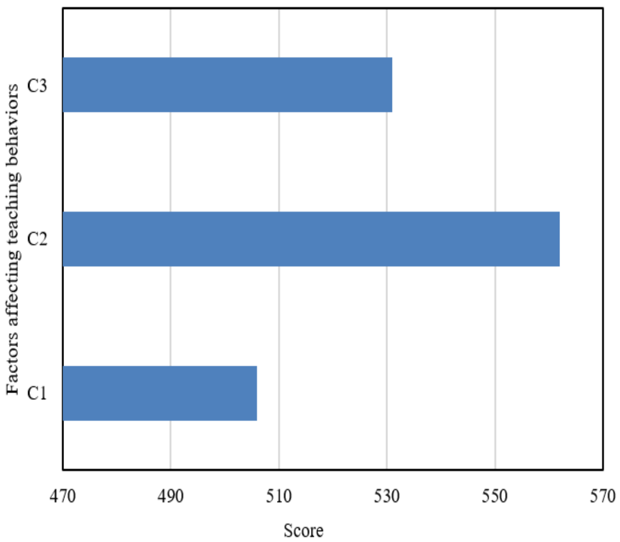

Figure 5. PE teachers' adaptability to teaching behaviors

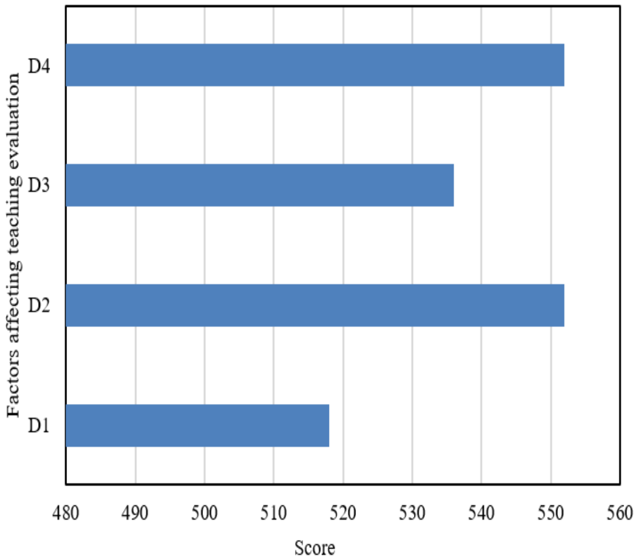

Figure 6. PE teachers' adaptability to teaching evaluation

During professional development, the adaptability of primary school PE teachers to teaching behaviors was measured by the composite scores of three factors: teaching preparation C1, teaching implementation C2, and teaching evaluation C3. As shown in Figure 5, the primary school teachers had the highest adaptability to C2, followed in turn by C1 and C3. This result is in line with the previous analysis. Most PE teachers have formulated a fixed teaching model. It takes a long time for them to fully adapt to the standards for professional development.

The adaptability of primary school PE teachers to teaching evaluation was measured by the composite scores of four factors: teacher quality D1, teaching design D2, teaching process D3, and teaching effect D4. As shown in Figure 6, D2 and D4 had the highest composite scores, indicating that the primary school PE teachers have basically mastered the evaluation model for professional development.

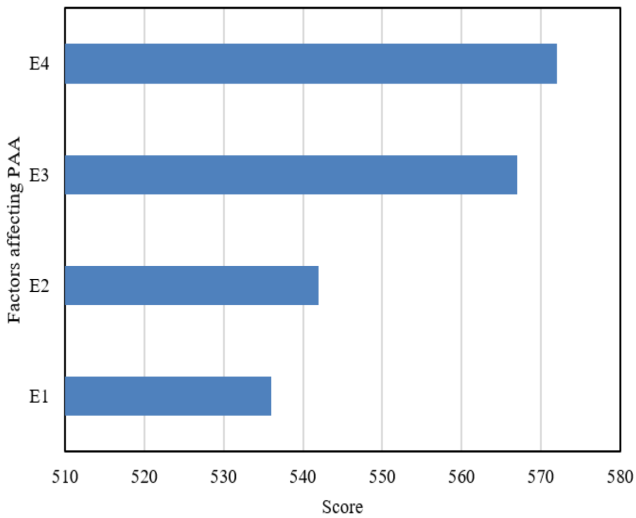

Figure 7. PAA of PE teachers pursuing professional development

During professional development, the PAA of primary school PE teachers is mainly affected by good mental state E1, stress resistance E2, ability to withstand anxiety E3, and good interpersonal relationship in education E4. As shown in Figure 7, the highest composite score was achieved in E4, followed in turn by E3, E1, and E2. The results show that the primary school PE teachers must maintain a good mental state, a sound teacher-student relationship, and a healthy relationship with peers, in order to better withstand the stress and anxiety induced by the rising work difficulty and load, in the pursuit of professional development.

Table 2

Gender difference of PETPD

	Cognitive level		Teaching concepts		Teaching behaviors		Teaching evaluation		PAA	
Gender	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Population	110	30	110	30	110	30	110	30	110	30
%	78.57	21.43	78.57	21.43	78.57	21.43	78.57	21.43	78.57	21.43
Mean	20.35	20.16	3.79	4.03	12.32	12.79	16.75	16.82	18.54	16.78
Intra-class difference	1.62		0.751		0.472		2.85		13.79	
Between-class difference	3.768		0.762		2.418		2.534		2.573	
F-statistic of ANOVA	0.423		0.765		0.172		1.034		5.527	
P-value (significant difference)	>0.05		>0.05		>0.05		>0.05		<0.05*	

Table 3

Age difference of PETPD

	Cognitive level		Teaching concepts		Teaching behaviors		Teaching evaluation		PAA	
Age	<45	≥45	<45	≥45	<45	≥45	<45	≥45	<45	≥45
Population	95	45	95	45	95	45	95	45	95	45
%	67.85	32.14	67.85	32.14	67.85	32.14	67.85	32.14	67.85	32.14
Mean	20.46	21.72	4.53	3.67	18.35	16.71	17.35	16.23	17.98	17.98
Intra-class difference	1.08		2.75		11.724		0.41		10.72	
Between-class difference	3.768		0.42		2.651		2.762		2.574	
F-statistic of ANOVA	0.279		6.71		5.14		0.156		4.167	
P-value (significant difference)	>0.05		<0.02**		<0.02**		>0.05		<0.05*	

Table 2 presents the gender difference of PETPD obtained through ANOVA. There are 110 males (78.57%) and 30 males (21.43%) among the objects. Under the influence of professional development standards, the PE teachers of different genders did not have significant differences in cognitive level, teaching concepts, teaching behaviors, or teaching evaluation. However, they differed significantly on PAA ($p<0.05$). The mean PAA of female PE teachers was 16.78, much lower than that (18.54) of male PE teachers. The main reason is that PETPD brings greater physiological and psychological stress to female teachers than to male teachers.

Table 3 displays the age difference of PETPD. Among the objects, 95 (67.85%) are young teachers (<45); 45 (32.14%) are middle-aged and old teachers. The primary school PE teachers in different age groups varied extremely significantly in teaching concepts and teaching behaviors ($p<0.02$), and significantly in PAA. There was no significant age difference in cognitive level and teaching evaluation.

Table 4

Multiple comparison results of PETPD under different professional titles

	Professional PE knowledge	Professional PE ability	Professional PE ethics	PAA
Junior/medium	0.94 (0.763)*	0.8 5(1.072)	1.63 (1.005)*	1.68 (0.876)*
Medium/senior	0.42 (1.15)	2.03 (1.617)*	0.89 (1.617)	0.36 (1.282)
Junior/senior	0.9 (1.234)*	2.46 (1.618)*	2.59 (1.572)*	1.34 (1.298)*

Furthermore, the PETPD of teachers with different professional titles were subjected to multiple comparisons. According to the results in Table 4, on the acquisition of professional PE knowledge, primary school PE teachers with junior professional titles differed significantly from those with medium professional titles (mean difference: 0.94; standard deviation: 0.763). Hence, those with junior titles lag those with medium titles in the dimension of professional PE knowledge in professional development.

On the acquisition of professional PE knowledge, primary school PE teachers with medium titles differed insignificantly from those with senior titles (mean difference: 0.42; standard deviation: 1.15). Thus, these two groups of teachers do not have significant difference in professional development.

On the acquisition of professional PE knowledge, primary school PE teachers with junior titles differed significantly from those with senior professional titles (mean difference: 0.9; standard deviation: 0.1234). In this dimension, primary school PE teachers with junior titles are not as professional as those with senior titles.

Table 5

PETPD difference among teachers of different education levels

	Cognitive level		Teaching concepts		Teaching behaviors		Teaching evaluation		PAA	
Education level	Undergraduate and below	Postgraduate	Undergraduate and below	Postgraduate	Undergraduate and below	Postgraduate	Undergraduate and below	Postgraduate	Undergraduate and below	Postgraduate
Population	90	50	90	50	90	50	90	50	90	50
%	64.28	35.71	64.28	35.71	64.28	35.71	64.28	35.71	64.28	35.71
Mean	21.35	17.28	4.56	4.52	12.37	10.93	17.03	15.42	16.71	19.32
Intra-class difference	15.31		0.062		37.523		16.75		55.08	
Between-class difference	3.62		0.512		2.176		2.435		2.314	
F-statistic of ANOVA	4.352		0.125		17.652		6.873		24.68	
P-value (significant difference)	<0.05*		>0.05		<0.02**		<0.02**		<0.02**	

On professional PE ability, primary school PE teachers with senior titles differed significantly from those with junior or medium titles. In this dimension, primary school PE teachers with senior titles develop better than their peers with other titles.

On professional PE ethics, primary school PE teachers with junior titles differed significantly from those with medium or senior titles. These teachers are less developed than their peers with other titles.

On PAA, primary school PE teachers with junior titles differed significantly from those with medium or senior titles. These teachers have lower PAA than those with other titles.

Overall, primary school PE teachers with senior titles have relatively good PETPD ability, while those with junior titles have relatively poor PETPD ability.

Table 5 shows the PAA difference among PE teachers of different education levels. About 64.28% (90) of the primary school PE teachers are undergraduates and below, and 35.71% are postgraduates (50). Under the influence of professional development standards, the primary school teachers differed significantly in cognitive level, teaching behaviors, teaching evaluation, and PAA. The primary school PE teachers with high education levels have stronger PETPD ability and better PAA than those with low education levels, without any significance difference in teaching concepts. The primary reason lies in the quality of these teachers. PETPD standards raise stricter requirements on the knowledge structure, thinking pattern, and teaching ability of primary school PE teachers, brining greater mental pressure on those with low education levels. As a result, the primary school PE teachers with low education levels are poorer in PAA.

Table 6

PETPD difference between different types of schools

	Cognitive level		Teaching concepts		Teaching behaviors		Teaching evaluation		PAA	
School type	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Population	65	75	65	75	65	75	65	75	65	75
%	46.42	53.57	46.42	53.57	46.42	53.57	46.42	53.57	46.42	53.57
Mean	19.05	22.67	4.514	4.514	11.36	13.84	15.63	17.29	16.37	17.81
Intra-class difference	22.375		1.376		20.917		1099		4.086	
Between-class difference	3.412		0.495		2.152		2.395		2.721	
F-statistic of ANOVA	6.543		2.726		9.504		4.623		1.582	
P-value (significant difference)	<0.02**		>0.05		<0.02**		<0.05*		>0.05	

Table 6 shows the PAA difference between schools of different types. Under the influence of professional development standards, the primary school PE teachers from different regions differed significantly in professional development level. For simplicity, the primary schools were divided into rural primary schools and urban primary schools. Among our objects, 65 (46.42%) work in rural primary schools, and 75 (53.57%) work in urban primary schools. The primary school PE teachers from different types of schools differed significantly in professional development level ($p<0.05$), and extremely significantly in cognitive level and teaching methods ($p<0.05$). This is attributable to the wide difference between rural and urban primary schools in infrastructure and faculty. The two types of schools offer very different chances of training and advanced learning to PE teachers, and create very dissimilar environments for PETPD. Relatively speaking, the PE teachers in urban schools adapt better to professional development than their rural counterparts.

6. Conclusions

This paper probes into the correlation between PETPD and PAA. After clarifying the structure of PETPD model, the authors constructed a PETPD EIS under the psychological adaptation of PE teachers. Next, a comprehensive PETPD evaluation model was established based on entropy weight – TOPSIS, and the PETPD prediction was detailed based on DNN. Through experiments, the predicted comprehensive level of PETPD was subjected to multi-way ANOVA, and the five aspects of the PAA of primary school PE teachers were rated under the professional development standards, including cognitive level, teaching concepts, teaching behaviors, teaching evaluation, and PAA. Then, the PETPD differences under different conditions were analyzed, namely, gender, age, professional title, education level, and type of school. The results demonstrate the effectiveness of our algorithm.

The limitation of research data may affect our research on the theory of PETPD. Besides, our analysis on the acquired information and current state might be a little bit one-sided. Not every factor affecting PETPD is thoroughly discussed, and some root causes could remain hidden. The future research will try to solve these limitations.

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