International Journal of Computer Information Systems and Industrial Management Applications
ISSN 2150-7988 Volume 17 (2025) pp. 1-15

https://doi.org/10.70917/ijcisim-2025-0278
Article

Mathematical Modeling and Optimization Path Research on Teaching Method Innovation of Physical Education Teachers in Colleges and Universities under Digital Teaching Environment

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Abstract: Under the digital teaching environment, traditional physical education teaching methods cannot meet students' learning needs. In this paper, through reviewing relevant information and literature, we determine the influencing factors of teaching method innovation of college physical education teachers, and set them as the research independent variables. Under this premise, multiple linear regression is used to complete the mathematical modeling task of the influence factors of teaching method innovation of college physical education teachers, and the model is used to develop the empirical analysis of college physical education teachers' teaching. The regression coefficients of the research variables were obtained as 0.119, 0.103, 0.105, 0.132, and the corresponding P-values were 0.002, 0.002, 0.005, 0.07, respectively, which satisfy the condition of $P<0.05$, indicating that there is a significant positive influence at the level of 5%, and that the teacher beliefs, teacher's work commitment, teacher's sense of efficacy, and teacher's reflection have a positive influence on the teacher's teaching method innovation with an explanatory power is 74.9%. In addition, based on the results of the analysis, a targeted path of optimization of physical education teaching methods is proposed, aiming to enhance the diversity and richness of teaching methods of college physical education teachers.

Keywords: multiple linear regression; mathematical modeling; optimization path; teaching method innovation

1. Introduction

With the development of digital technology, physical education has ushered in a new opportunity for transformation [1]. The application of tools such as wearable monitoring, motion capture and virtual simulation enables the training process to be data-driven and visualized, providing conditions for personalized instruction and dynamic adjustment [2-3]. Digital teaching, on the other hand, is a teaching method that utilizes e-technologies such as the above to enhance students' learning experience and provide a wide coverage of online learning opportunities, and common digital teaching includes online learning and blended learning systems [4-5]. Digital teaching follows the 3 mechanisms of technology for learning, i.e., technology application, skill extension, and human-computer coexistence, and is a system of educational theory and practice centered on digital pedagogy [6-7]. The digital platform can realize the structured presentation and hierarchical management of training content, so that students of different levels can obtain differentiated instruction under the same teaching framework [8].

The teaching integration mechanism is mainly embodied in the embedding of digital tools into the teaching process, such as the use of motion capture and video analysis technology to achieve movement quality assessment, combined with an online interactive platform to carry out post-class review and Q&A, forming a closed-loop structure of classroom, training and feedback [9-10]. Flexibility and personalization are the core advantages of digital teaching, teachers can adjust the teaching content and

methods according to the learning progress and needs of each student, and using intelligent platforms, teachers can monitor the students' learning status and progress in real time, give personalized feedback, and optimize teaching methods [11-13]. In addition, digital teaching helps students to carry out independent learning and cooperative learning, using online discussions, virtual experiments and social interaction platforms, students can continue to invest in learning outside the classroom to broaden their learning horizons and enhance the depth of learning [14-15]. Accompanied by the continuous progress of technology, the digital teaching mode will further promote the innovation and transformation of educational forms, which promotes the scientific innovation of teaching methods for physical education teachers [16].

With the development of sensing technology, deep learning and big data, sports action recognition plays an increasingly important role in the innovation of physical education teaching mode [17]. Zhier[18](2016) built a sports teaching system using Kinect platform to be able to realize 3D human motion capture, combined with the OGRE graphic rendering engine to store and 3D motion reconstruction of motion data, and then achieve quantitative analysis of the learning quality of sports movements through dynamic practice regularization method. Chen et al. (2022)[19] combined Kinect sensor and machine learning algorithms to accurately identify the classroom teaching behaviors of physical education teachers, in which the Kinect sensor acquired different behavioral gesture characteristics of teachers in a simulated classroom, and then the lightweight gradient lifting machine recognition model was used for the recognition of behaviors. The final accuracy rate reaches 99.8%. Ding et al.(2022)[20] constructed a physical education teaching effectiveness evaluation system, which integrates the action recognition model and multispectral map reproduction technology, and can achieve color-appearance matching in the space independent of the observation conditions, and shows a good facilitation in the recognition of physical education skills, and teaching effectiveness. Lin et al.(2023)[21] based on the machine vision principle and the human bone and joint model as the in vitro research support, not live the human body movement posture and movement information, through the image enhancement and binarization processing to improve the image resolution, which can accurately capture the physical behavior of the students in sports training. Lu et al. (2025)[22] in order to innovate the teaching mode of secondary school physical education to put forward a kind of movement capture algorithm based on the convolution neural network and the long-time memory network, through the self-made capture algorithm, the performance test is conducted through the self-made student physical activity model, in which the Loss value of the fusion algorithm converges to 0.045 and the accuracy rate reaches 92.1%, which has practical application value.

Since the 1980s, scholars have been exploring how to promote the deep integration of intelligence with the field of education as the application of artificial intelligence continues to develop, and this topic has become a persistent research theme, triggering the generation of a series of theoretical models [23-24]. Huang et al. (2011)[25] developed a web-based learning platform for physical education and incorporated a variety of sports-related course materials, and found that sports digital materials effectively improved students' learning efficiency and stimulated their interest in physical education learning, and teachers could accurately grasp students' learning situation to reduce the burden of teaching by utilizing the platform. Zhou (2016)[26] found through a questionnaire that multimedia web-based teaching platforms have a positive impact on physical education teaching, especially in terms of the teaching concepts, teaching environments, teaching contents, and innovative methods were highly recognized by the investigators. Da-Wei et al. (2018)[27] constructed a digital teaching platform that provided students with sports videos, sports teaching animations, etc., under which students showed full motivation, and students used the flexibility and popularity of the network to learn more sports skills, and the teaching effect was better than the traditional physical education teaching mode. Aksi et al. (2024)[28] applied a digital platform for physical education teaching in Tanggulbatombo No. 1 Primary School in Mangasi City, using a pre and post-test experimental design to study students' interest in physical education learning and academic performance, and the study showed that the average increase in students' interest in learning under the intervention of the digital platform amounted to 84.5%, while the average increase in their academic performance was 68.9%. Li et al. (2024)[29] constructed a physical education teaching platform based on multimedia networks and various short videos to build a sports video resource platform, based on which a data-driven adaptive teaching method was designed, and students' satisfaction increased by 25% and learning efficiency by 30% in the immersive learning environment provided by the platform.

Meanwhile, in recent years, some researchers have integrated intelligent algorithms for motion recognition into traditional online learning platforms, combined sports online resources with sports practice, and further optimized the shortcomings of traditional sports teaching. Luo(2023)[30] introduced the Open Pose framework as the main method of pose recognition in sports teaching in order to improve the practical effect of digital education platforms in sports training In order to improve the

practice of digital education platform in sports training, Open Pose framework was introduced as the main method of posture recognition in sports teaching, and the recognition performance of the framework was further enhanced by combining the self-attention mechanism, and the prediction error of the framework was lower than 1.5cm in the training practice, which has great potential to be applied in sports training. Wu et al. (2024)[31] pointed out that digital education platforms can help online physical education teaching to be more complete and efficient, and they embedded a random forest algorithm in digital platforms aiming at recognizing students' sports movements during training, and the algorithm's recognition accuracy reached 99%, which further consolidated the core position of digital platforms in physical education teaching.

In addition, Palao et al. (2015)[32] explored the impact of visual feedback based on digital video technology on students' performance in sports, and they found that the two factors of "video and teacher feedback" play a positive role in students' execution improvement, skill development, and knowledge learning, etc. Koekoek et al. (2018)[33] proposed an innovative educational model combining digital video technology and physical education game teaching, which was learned through a case study to fully utilize digital resources for physical education teaching and to develop students' logical thinking skills in games. Zulkifli et al. (2022)[34] used an exploratory research design to analyze the effects of a motor program on the improvement of students' motor skills , with 25 trial participants synthesizing that this method increased their engagement and ownership of learning content, providing coaches with more accurate feedback on student training.

Although digital technology has achieved rich research results in the innovation of physical education teaching methods, there are still challenges in the digital teaching of physical education courses [35-37]: first, the online part mainly undertakes the tasks of theoretical lectures, courseware downloads, and sports data recording, while the offline part focuses on practical skills and on-site coaching, and the articulation between the two is not entirely satisfactory. Secondly, due to the combination of insufficient depth and limitations in breadth, the potential value of digital technology has not been fully utilized, making it difficult to achieve the goals of personalized teaching and precise training. Third, although most teachers are skilled in operating multimedia courseware and network platforms, they are limited in higher-order applications such as data modeling and virtual simulation.

Starting from the existing research data, the influencing factors of physical education teachers' teaching method innovation are clarified, which include teachers' beliefs, teachers' work commitment, teachers' sense of efficacy and teachers' reflection, which are set as the independent variables, while the dependent variable is teachers' teaching method innovation. On this basis, a multiple linear regression model is constructed for the influencing factors of college physical education teachers' teaching method innovation, and the corresponding test method is given. After completing the preparation of the study, the questionnaire of this study is designed, which can be used for data collection in view of its excellent reliability and validity performance. Through the distribution of the questionnaire to obtain the research data, and then use the model of this paper to carry out in-depth exploration of the teaching methods of college physical education teachers, and put forward the optimization path of the teaching methods of physical education teachers.

2. Influencing Factors and Modeling of Teaching Method Innovation for Physical Education Teachers

2.1. Influencing factors

2.1.1. Teachers' beliefs

Teaching beliefs are the teachers' basic views on teaching-related issues based on their own intellectual, logical, experiential, social, or emotional views, which they evaluate. Therefore, having the right beliefs will help teachers to uphold the right concepts of teaching and learning, which will also promote the implementation of innovative teaching and learning. Possessing wrong beliefs about teaching will hinder the change of teachers' teaching concepts, which will also affect the implementation of innovative teaching.

2.1.2. Teachers' work input

As educators, the level of teachers' commitment to their work plays an important role in the process of their innovative teaching. In such a process, in which the worker and the role are in a dynamic transformation of each other: with a high level of worker engagement, they help themselves to be able to focus their energies on their role behaviors and to present themselves in the process of their work. On the contrary, workers with low engagement will withdraw, withdrawing from the work, in order to prevent themselves from creating the performance that is needed for the work, and workers in this state may give

up the work.

2.1.3. Teachers' sense of efficacy

Teachers with a high sense of efficacy are open to new ideas and are more likely to be willing to experiment with new teaching methods in order to meet the needs of their students. A teacher's sense of teacher efficacy also has an impact on teacher motivation, and teachers with a high sense of efficacy tend to have high levels of motivation to teach innovatively. Motivation serves as an internal agent that inspires and sustains human action and can direct that action toward a goal to satisfy an individual's needs.

2.1.4. Teacher reflection

Through pedagogical reflection, teachers will be able to identify new problems in teaching and learning, thus stimulating the motivation of teachers to strive to improve their own teaching, so that they will always be in the process of constantly making changes in teaching and learning, and upgrading their teaching practice to a more reasonable level. The reason why teachers reflect on their teaching is to further improve their teaching, which is actually an effort to work towards a more rational teaching practice. Teachers' reflection on teaching is also an effective way to bridge the gap between teaching theory and teaching practice. Teaching reflection can also improve teachers' teaching and research ability, through teaching and research teachers find their own problems, and directly promote teachers to develop.

In order to study the general relationship of quantitative changes between variables, it is usually necessary to choose a suitable mathematical model to describe the general relationship on the quantitative changes between phenomena, this mathematical method is called regression analysis [38-39]. Correlation is a quantitative relationship between variables is not strict and not fixed interdependence, to find out the general relationship between the quantitative change of this relationship value or average, that is, to find out the general rules of this relationship quantitative change, the method is to cooperate with the corresponding straight line or curve, if the cooperation is a straight line is called a regression straight line, the curve is called a regression curve. Regression analysis with only one independent variable is called univariate regression analysis, and regression analysis with more than one independent variable is called multiple regression analysis. Through the construction of multiple regression model to reveal the relationship between different influencing factors and teachers' teaching innovation ability, and then provide a strong theoretical basis for the design of college physical education teachers' teaching method innovation path. The process of constructing the multiple linear regression model is as follows:

2.2. Mathematical modeling

2.2.1. Multiple linear regression equations

When there are k explanatory variables that have a significant effect on the explanatory variable Y, namely $x_1, x_2, \cdots, x_k$ and Y is linearly related to $x_1, x_2, \cdots, x_k$ is linearly correlated, the regression model can be generalized with n equations:

$$Y_t = \beta_0 + \beta_1 X_{1t} + \beta_2 X_{2t} + \cdots + \beta_k X_{kt} + \varepsilon_t (t = 1, 2, \ldots, n) \quad (1)$$

The sample regression model corresponding to the multiple linear regression overall regression model is:

$$y_t = b_0 + b_1 x_{1t} + b_2 x_{2t} + \ldots + bkx_{kt} + \varepsilon_t (t = 1, 2, \ldots, n) \quad (2)$$

The sample regression equation is:

$$y = b + bx + bx + \cdots + bx (t = 1, 2, \cdots, n) \quad (3)$$

Where $\beta_0, \beta_1, \beta_2, \cdots, \beta_k$ is the overall regression parameter; $b_0, b_1, b_2, \cdots, b_k$ is the sample regression parameter; ε : is the error term, which reflects the effect of random factors on y other than the linear relationship between $x_1, x_2, \cdots, x_k$ and y. It is the effect of random factors on y that cannot be accounted for by the $x_1, x_2, \cdots, x_k$ and variability explained by the linear relationship between y. Where b_1 has the meaning of the average change in the dependent variable Y caused by each unit change in the independent variable, holding other influences constant. The meanings of $b_2, b_3, \cdots, b_k$ are analogous.

Note that in a multiple linear regression model, there is no strict linear relationship between the independent variables, i.e., there is no multicollinearity, otherwise the meaning of the regression coefficients cannot be explained.

Let the dependent variable y be affected by k independent variables $x_1, x_2, x_3, \cdots, x_k$, and its regression equation is:

$$y_c = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + \cdots + b_k x_k \tag{4}$$

where $a, b_i (i = 1, 2, 3, \cdots, k)$ are parameters.

According to the principle of the least square method, $\sum (y - y_c)^2 =$ is minimized. Since there are $k+1$ parameters, $k+1$ equations should be determined:

$$\left\{ \begin{array}{l} \sum y = na + b_1 \sum x_1 + b_2 \sum x_2 + \cdots + b_k \sum x_k \\ \sum x_1 y = a \sum x_1 + b_1 \sum x_1^2 + b_2 \sum x_1 x_2 + \cdots + b_k \sum x_1 x_k \\ \sum x_2 y = a \sum x_2 + b_2 \sum x_2^2 + b_1 \sum x_1 x_2 + \cdots + b_k \sum x_1 x_k \\ \vdots \\ \sum x_k y = a \sum x_k + b_1 \sum x_1 x_k + b_2 \sum x_2 x_k + \cdots + b_k \sum x_k^2 \end{array} \right\} \tag{5}$$

2.2.2. Degree of fit test

In multiple linear regression, the total sum of squared deviations TSS of the dependent variable Y is the same as in univariate linear regression, and we can divide it into two parts: one part is the regression sum of squared deviations RSS that can be explained by the regression equation; and the other part is the residual sum of squared deviations ESS that cannot be explained by the regression equation.

In multivariate linear regression, the principle of determining the degrees of freedom of each variable is as follows: the degrees of freedom of the total sum of squared deviations is df TSS=n-1, the degrees of freedom of the regression sum of squared deviations is df RSS=k, and the degrees of freedom of the residual sum of squared deviations is df ESS=n-k-1. The respective sums of squared deviations are divided by the corresponding degrees of freedom, which gives us the corresponding mean squared deviations.

2.2.3. Significance Test

In univariate linear regression, it is easy to understand that the test of the regression equation (F-test) and the test of the regression coefficients (t-test) are equivalent. However, in multiple regression, these two tests are no longer equivalent. The following is a detailed description of each. There is a difference between the purpose of t-test and F-test, t-test is to test the significance of individual regression parameters in the model, and F-test is to test the significance of the regression model as a whole.

(1) Test of regression equation: F-test

The first step is to formulate the original hypothesis.

The original hypothesis $H_0 : \beta_1 = \beta_2 = \ldots = \beta_k = 0$ (i.e., assuming that the overall regression model linearity is not significant).

The alternative hypothesis $H_1 : \beta_i (i = 1, 2, \ldots, k)$ has at least one non-zero.

In the second step, calculate the statistic for the test.

In the third step, make a statistical decision.

Given the significance level α, the value of $F_a(k, n-k-1)$ is obtained by checking the F distribution table according to the degrees of freedom and then compared. If $F > F_a$, H_0 is rejected, thus the linear relationship of the overall regression model is considered significant and the model passes the significance test. Otherwise, H_0 is accepted, thus the linear relationship of the overall regression model is considered insignificant and the model fails the significance test.

(2) Test of regression coefficients: t-test

In contrast to the test of the regression model, the test of regression coefficients is a separate test for each regression coefficient, which is mainly used to test whether the effect of each independent variable on the dependent variable is significant. If an independent variable does not pass the test, it means that the effect of that independent variable on the dependent variable is not significant, and it may not be necessary to put that independent variable into the regression model.

The steps to perform a t-test are as follows:

In the first step, the original hypothesis is formulated.

The original hypothesis $H_0 : \beta_i = 0, (i = 1, 2, \ldots, k)$ (i.e., hypothesize that the variable x_i is insignificant).

Alternative hypothesis $H_1 : \beta_i \neq 0$

In the second step, calculate the statistic for the test:

Step 3, make a statistical decision.

Given the significance level α , look up the t-distribution table based on the degrees of freedom to get the critical value $t_{\alpha/2}(n-k-1)$, and then compare.

If $ti > t_{\alpha/2}$, then H_0 is rejected, and thus the variable x_i is considered to be significant, and the regression coefficient b_i passes the significance test. Otherwise, H_0 is accepted and thus the variable x_i is considered insignificant, the regression coefficients b_i fails the test of significance and it should be excluded from the regression equation.

3. Statistical Analysis of Physical Education Teachers' Teaching Method Innovation

3.1. Questionnaire design and analysis

3.1.1. Questionnaire design

With reference to the existing research and related scales, from the teaching method innovation composition to start hair, combined with the author's participation in the middle physical education teaching training experience, for the physical education teaching method innovation of the four dimensions of the influencing factors to design the questionnaire questions. 4 influencing factors as the independent variable, physical education teaching method innovation as the dependent variable. In response to the actual situation, the author prepared a questionnaire form of influencing factors, the questionnaire consists of three parts, involving a total of 26 questions. The first part of the questionnaire is the description of the questionnaire. It briefly explains the purpose of the questionnaire and facilitates the respondents to fill in the questionnaire. The second part of the questionnaire is the basic personal information of the sample of respondents, specifically including age, education, title, position and other six topics. The third part is the main body of the questionnaire including 20 topics. It includes 4 items of teachers' beliefs, 4 items of teachers' work commitment, 4 items of teachers' sense of efficacy, 4 items of teachers' reflection, and 4 items of innovation in teaching physical education methods. Each measured variable was measured using Likert's (Likert) 5-point scale as a measurement tool, with 1 indicating no mastery at all (not carried out), 2 indicating no mastery, 3 indicating average, 4 indicating basic mastery, and 5 indicating complete mastery.

3.1.2. Analysis of questionnaires

(1) Data collection and processing

The purpose of this study is to investigate the influencing factors affecting the innovation of teaching methods of physical education teachers, the degree of influence of each factor on the innovation of teachers' teaching methods, and the interaction relationship between each influencing factor. In this study, physical education teachers of a four colleges and universities were randomly selected as the questionnaire respondents, and the selected questionnaire respondents were mainly for the physical education teachers on staff in colleges and universities. Teachers fill out the questionnaire through the cell phone mobile terminal, a total of 500 questionnaires were issued, questionnaires were identified and screened after the recovery of the questionnaires, 36 invalid questionnaires were removed, and 464 valid questionnaires were obtained, with an effective recovery rate of 92.8%.

The questionnaire survey needs to be modified

1. Survey School: 4 schools modified over 10 schools

2. 93 valid questionnaires were revised from 500 in-service physical education teachers to 97 survey

teachers

Sample size: Questionnaires were distributed to 10 schools in cities such as Guangzhou, Zhaoqing, Dongguan, Huizhou, Zhuhai, and Zhongshan in the Pearl River Delta of Guangdong Province. A total of 97 questionnaires were collected, and 93 valid questionnaires were collected.

The data of this sample was analyzed through SPSS22.0, AMOS21.0 related analysis software.

(2) Exploratory factor analysis

In this study, the valid data of the questionnaire were further dimensionalized by exploratory factor analysis, so that the variables with higher degree of correlation were clustered together, and each common factor was represented by a class of clustered variables. In this analysis process, the first step requires KMO value calculation as well as testing, and the test of KMO and Bartlett sphericity is shown in Table 1. The result of data analysis shows that (KMO value is 0.907>0.6, which indicates that the observed variables are suitable for factor analysis and secondly Bartlett's test of sphericity gives a test value of X^2 of about 4608.439, Degree of Freedom DF of 147, P-value=0.0003, which is less than the level of significance of 0.05 in terms of the statistical requirements, so the null of the Bartlett's test of sphericity was rejected) hypothesis, so the data of this sample is suitable for factor analysis. Then the next step of analysis will be carried out.

Table 1. KMO and Bartlett's test.

The measurement of the suitability of KMO sampling		0.907
Bartlett sphericity test	Approximate chi-square	4608.439
	Degree of freedom	147
	Significance	0.0003

Through exploratory factor analysis, a total of 5 common factors were obtained, and the total variance interpretation rate is shown in Table 2. The five common factors respectively explained 21.58%, 20.645%, 10.745%, 10.38% and 8.7% of the variance of the 20 items. In total, they cumulatively explained 72.05% of the variance of all items, reflecting the vast majority of the original variables and meeting the statistical requirements. Therefore, it can be indicated that the results of the extraction of the common factors for this exploratory factor analysis conducted are satisfactory. And these five factors were named as teacher beliefs, teacher work commitment, teacher efficacy, teacher reflection, and innovation in teaching physical education methods.

Table 2. Total Variance Explained.

N	Initial eigenvalue			Extract the sum of squares of the loads			The sum of the squares of the rotational load		
	Total	Variance	Cumulative	Total	Variance	Cumulative	Total	Variance	Cumulative
1	8.306	0.4153	0.4153	8.306	0.4153	0.4153	4.316	0.2158	0.2158
2	3.254	0.1627	0.578	3.254	0.1627	0.578	4.129	0.20645	0.42225
3	1.118	0.0559	0.6339	1.118	0.0559	0.6339	2.149	0.10745	0.5297
4	0.978	0.0489	0.6828	0.978	0.0489	0.6828	2.076	0.1038	0.6335
5	0.754	0.0377	0.7205	0.754	0.0377	0.7205	1.74	0.087	0.7205
6	0.508	0.4153	0.4153						

Then principal component analysis was used to factor analyze the above data, and diagonal rotation was done on the factor loading matrix, using eigenvalue greater than 1 as the criterion for principal component retention. Factors with factor loading coefficients ≧ 0.6 were extracted, and it was necessary to exclude the existence of the question items with factor loading too low (<0.6) or multiple loading (loading values on two and more factors exceeding 0.6 at the same time), and the rotated factor matrix was shown in Table 3. There was no cross-loading among the factors, and the factor loading coefficients of each latent variable relative to the corresponding factor were all greater than 0.6. Therefore, the factor analysis of the scale items using principal component analysis in this paper was acceptable.

Table 3. Rotated component matrix.

Item	Teacher's belief	Teacher's work engagement	Teacher efficacy	Teacher's Reflection	Innovation in physical education method teaching
1	0.874				
2	0.898				
3	0.818				

4	0.821				
5		0.863			
6		0.859			
7		0.822			
8		0.814			
9			0.863		
10			0.802		
11			0.891		
12			0.884		
13				0.828	
14				0.809	
15				0.883	
16				0.808	
17					0.829
18					0.882
19					0.876
20					0.817

(3) Reliability analysis

The questionnaire research data were analyzed for intrinsic reliability, and the reliability test of the questionnaire is shown in Table 4. The overall Colombach coefficient of the questionnaire is 0.9008, the reliability coefficient of teachers' beliefs is 0.929, the reliability coefficient of teachers' work commitment is 0.909, and the reliability coefficient of teachers' sense of efficacy is 0.906, all of which are at 0.900 and above, and their reliabilities have reached the best values. The reliability coefficients of teachers' reflection and teachers' innovation in teaching methods are also greater than 0.85, indicating that the questionnaire has high reliability.

Table 4. Reliability testing of the questionnaire.

Content	Cronbach's α
Teacher's belief	0.929
Teacher's work engagement	0.909
Teacher efficacy	0.906
Teacher's Reflection	0.888
Innovation in physical education method teaching	0.872
Total	0.9008

In this study, the correlation between the items and the total score of the questionnaire, the correlation between the dimensions and the correlation between the dimensions and the total score were used as the structural validity analysis, and the correlation between the dimensions of the questionnaire is shown in Table 5. The correlation between the dimensions is in the range of 0.239-0.787, thus, proving that the validity of the author's questionnaire is good.

Table 5. The correlation among the dimensions of the questionnaire.

Content	Teacher's belief	Teacher's work engagement	Teacher efficacy	Teacher's Reflection	Innovation in physical education method teaching
Teacher's belief	0.716**				
Teacher's work engagement	0.787**	0.554**			
Teacher efficacy	0.759**	0.348**	0.586**		
Teacher's Reflection	0.749**	0.239**	0.479**	0.718**	
Innovation in physical education method teaching	0.626**	0.575**	0.425**	0.308**	0.302**

3.2. Statistical analysis

3.2.1. Descriptive statistical analysis

After analyzing the collected data, the results of descriptive statistical analysis are shown in Figure 1. The research finds that the average values obtained by college physical education teachers in the five dimensions of teacher belief, teacher work engagement, teacher efficacy, teacher reflection, and teacher teaching method innovation are 3.510, 3.462, 3.433, 3.436, and 3.431 respectively, all ranging from 3.40 to 3.60. This indicates that the teaching method innovation ability of physical education teachers in colleges and universities generally remains at a good level at present. The scores of college physical education teachers in the three dimensions of "teacher efficacy", "teacher Reflection", and "Teaching method innovation" are all slightly lower than the overall average score of 3.45, indicating that it is necessary to strengthen and improve in these three dimensions. Especially in the dimension of "method innovation", the score among various abilities is the lowest, which requires teachers to pay sufficient attention. In the future process of physical education teaching in colleges and universities, efforts should be made to improve.

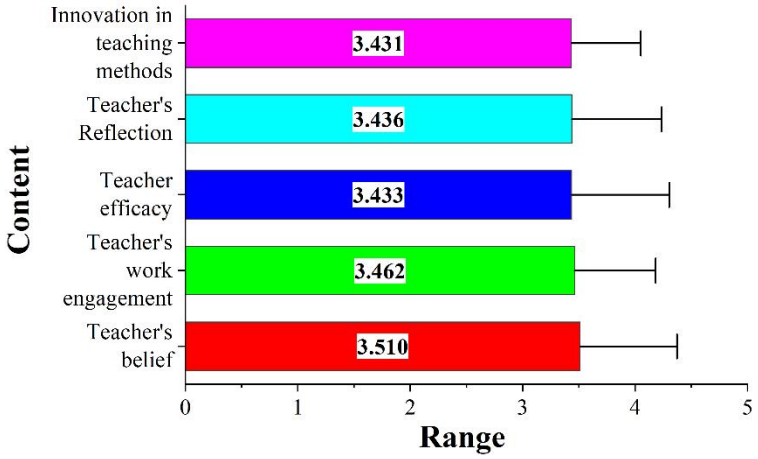

Figure 1. Descriptive statistical analysis results.

3.2.2. Analysis of variances

(1) Differential analysis of different genders

The specific scores of physical education teachers of different genders on teacher beliefs, teacher work commitment, teacher sense of efficacy, teacher reflection, and teacher teaching method innovation are shown in Figure 2, which shows that: as a whole, there is not much difference between the scores of males and females on each dimension. The scores of female teachers on teacher engagement, teacher efficacy, and teacher innovation in teaching methods are higher than those of male teachers, which suggests that female teachers have a higher level of pedagogical innovativeness in innovative teaching practices in general, while male teachers are better at teacher reflection and improving teacher beliefs.

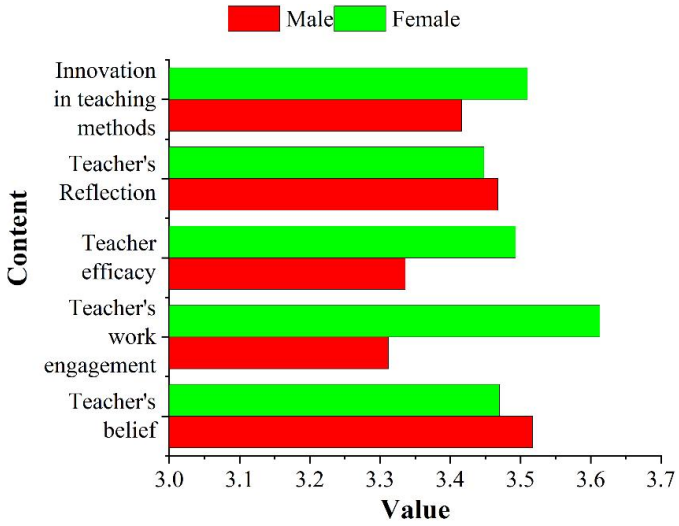

Figure 2. The scores of different genders in each dimension.

Because in terms of gender, the study is only divided into male and female groups for statistics, so in the SPSS 22.0 software, the study for the test of differences between the different genders, choose to use the independent samples t-test, the results of the analysis of differences between the different genders are shown in Table 6. The average difference between male and female teachers of physical education in colleges and universities in terms of innovation in teaching methods and competence in all dimensions is not very large, and none of them are significantly different. As a result, it can be said that there is no significant effect of gender on teaching method innovation of physical education teachers ($P<0.05$) with values of 0.716, 0.058, 0.331, 0.892, and 0.445, respectively.

Table 6. Analysis of gender differences.

Variable	Male		Female		T-Value	P-Value
	Mean	SD	Mean	SD		
Teacher's belief	3.508	0.905	3.435	0.887	0.349	0.716
Teacher's work engagement	3.306	1.086	3.606	1.035	-1.927	0.058
Teacher efficacy	3.328	1.049	3.487	1.156	-0.979	0.331
Teacher's Reflection	3.459	1.069	3.439	0.927	0.127	0.892
Innovation in physical education method teaching	3.408	0.856	3.505	0.826	-0.749	0.445

(2) Differential analysis of different teaching ages

The specific scores of physical education teachers of different teaching ages on teacher beliefs, teacher work commitment, teacher efficacy, teacher reflection, and teacher teaching method innovation are shown in Figure 3. Teachers' beliefs increased with the increase of teaching age, which was due to the gradual deepening of teachers' beliefs in the actual teaching process. As for the sense of teacher efficacy, teacher reflection, and teacher teaching method innovation, they basically show an upward trend with the growth of teaching age, but they also fluctuate.

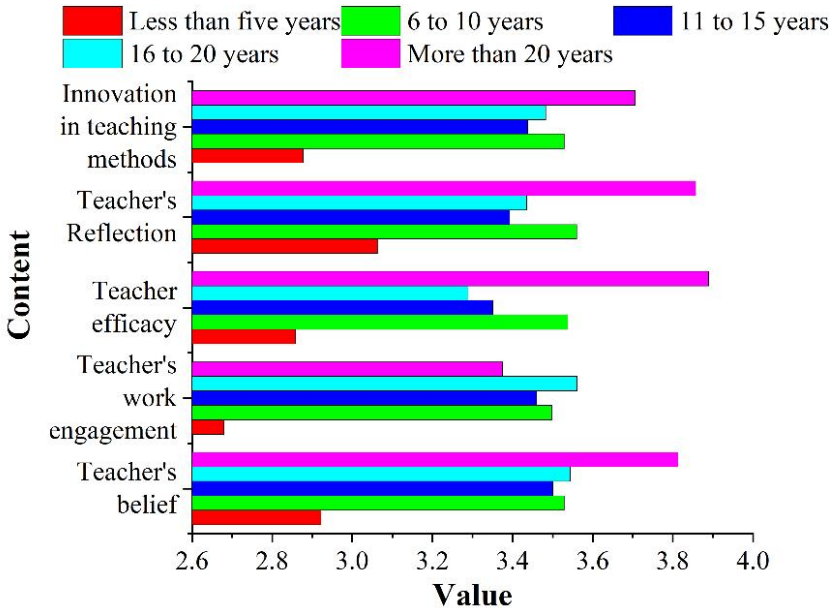

Figure 3. The scores of different teaching experiences in various dimensions.

In terms of teaching experience, the study was divided into five groups for statistics: "less than 5 years", "6-10 years", "11-15 years", "16-20 years", and "more than 20 years". Therefore, in the software SPSS 22.0, the study chose to use the ANOVA test for the difference test of different teaching experiences. The difference analysis of different teaching experiences is shown in Table 7. According to Table 7, for college physical education teachers, teaching years have a significant impact on the innovation of teaching methods ($P=0.041$). With the continuous increase of teaching years and the gradual accumulation of teaching experience, the innovation of teaching methods will also develop accordingly. However, the length of teaching has no significant influence on the four dimensions of "teacher belief ($P=0.054$)", "teacher work engagement ($P=0.059$)", "teacher efficacy ($P=0.056$)" and "teacher reflection ($P=0.196$)". This indicates that even if the teaching time is long, it does not mean that the development of each dimension can be balanced.

Table 7. Analysis of Differences among different Teaching Seniority.

Variable	Less than 5 years		6-10years		11-15years		16-20years		Than 20years		T-Value	P-Value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Teacher's belief	2.916	0.204	3.524	0.116	3.505	0.106	3.537	0.138	3.806	0.187	2.306	0.054
Teacher's work engagement	2.675	0.256	3.489	0.136	3.455	0.119	3.555	0.149	3.368	0.268	2.216	0.059
Teacher efficacy	2.854	0.266	3.529	0.137	3.346	0.124	3.284	0.167	3.884	0.218	2.275	0.056
Teacher's Reflection	3.057	0.269	3.555	0.128	3.387	0.114	3.428	0.156	3.849	0.214	1.511	0.196
Innovation in teaching methods	2.868	0.188	3.524	0.106	3.429	0.089	3.477	0.127	3.703	0.202	2.416	0.041

(3) Analysis of the differences among various professional titles

The specific scores of college physical education teachers with different professional titles in terms of teacher belief, teacher work commitment, teacher efficacy, teacher reflection, and teacher innovation in teaching methods are shown in Figure 4. From this, it can be known that, on the whole, the higher the professional title of a physical education teacher, the higher the score for innovative teaching methods. College physical education teachers with intermediate professional titles perform better than senior teachers in terms of "teacher belief", "teacher work commitment", "teacher efficacy" and "teacher teaching method innovation". This might be because senior teachers have higher requirements for themselves, clear development goals, or are more modest in their self-evaluation.

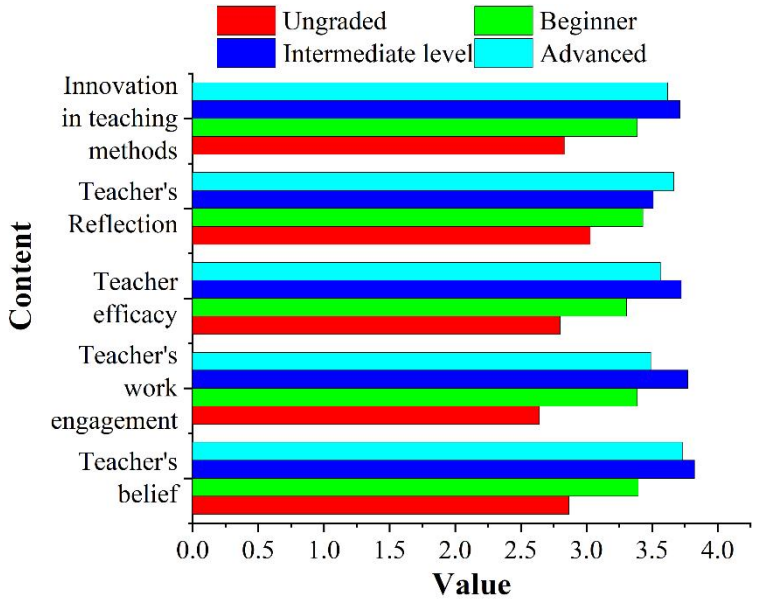

Figure 4. The scores of different professional titles in various dimensions.

In terms of professional titles, the study was divided into four groups for statistics: "Ungraded", "junior", "intermediate" and "senior". Therefore, in the software SPSS 22.0, the study chose to use the ANOVA test for the difference test among different professional titles. The analysis of the differences among different professional titles is shown in Table 8. For college physical education teachers, there is a significant effect of title on teaching method innovation (P=0.005). There was also a significant effect of title on the dimensions of teacher beliefs (P=0.003), teacher work commitment (P=0.007), and teacher efficacy (P=0.004).

Table 8. Analysis of the Differences among Various professional Titles.

Variable	Ungraded		Beginner		Intermediate level		Advanced		T-Value	P-Value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Teacher's belief	2.859	0.204	3.388	0.078	3.817	0.116	3.726	0.134	5.438	0.003
Teacher's work engagement	2.636	0.269	3.379	0.088	3.767	0.167	3.485	0.179	4.148	0.007
Teacher efficacy	2.795	0.278	3.312	0.114	3.716	0.154	3.557	0.156	2.217	0.004
Teacher's Reflection	3.024	0.288	3.425	0.088	3.505	0.175	3.559	0.144	1.445	0.067

Innovation in teaching methods	2.826	0.202	3.384	0.069	3.706	0.128	3.509	0.128	4.386	0.005

3.2.3. Regression analysis

In this study, regression method was used to explore the role mechanism affecting teachers' teaching method innovation with teachers' beliefs, teachers' work input, teachers' sense of efficacy, and teachers' reflection as independent variables and teachers' teaching method innovation as dependent variables, and the results of regression analysis are shown in Table 9. Teachers' beliefs, teachers' work input, teachers' sense of efficacy, teachers' reflection and teachers' teaching method innovation have a significant positive effect, and the regression coefficients are in the order of 0.119, 0.103, 0.105, 0.132. The adjusted coefficient of determination is 0.749, which indicates that the explanatory power of the independent variable on the dependent variable is 74.9%, revealing the role of the mechanism of the innovation of teachers' teaching method.

Table 9. Regression analysis results.

Project	Non-standardized coefficient		Standardization coefficient	T-Value	P-Value
	B	Standard error	Beta		
Constant	0.016	0.027		3.737	0.001
X1	0.119	0.028	0.118	4.807	0.002
X2	0.103	0.019	0.102	4.756	0.002
X4	0.105	0.033	0.107	4.737	0.005
X5	0.132	0.025	0.131	3.692	0.007
R^2	0.748				
Adjust R^2	0.749				
F	10.117				

4. Optimization of pathways

Based on the results of the statistical analysis in Chapter 3, the role of the relationship between the factors influencing the innovation of teaching methods of college physical education teachers is understood, and in order to improve the quality of physical education teaching in colleges and universities, a few points are proposed to optimize the teaching path of physical education teachers in colleges and universities. Details are as follows:

4.1. Enhance the comprehensive quality level of physical education teachers

Quality education has spread into the higher education industry, and the importance of quality education has been increasingly emphasized in sports. Physical education teachers should be more rigorous to improve their own quality to cope with the development of the times, physical education teachers are the embodiment of the overall level of the industry. Therefore, teachers should squarely focus on the use of teaching methods to reflect the overall quality of the team of sports workers. In addition, physical education teachers should also pay attention to other fields of study, and constantly enrich their own mastery of the various professions, physical education teachers only to improve their overall quality level will highlight their professionalism in physical education and the high quality of modern physical education teachers.

4.2. Physical education teachers need to learn more about teaching methods

The generation of teaching methods requires the development of rational teaching programs that take into account the learning patterns of students and their adaptability. Teachers should be aware of the content of the selected method and other factors, and organize the teaching with their own comprehensive quality ability. Teachers should face and strengthen the effective combination of teaching and learning, so that the two can be linked to achieve good results. They should also strengthen the combination of traditional physical education teaching and new physical education teaching methods in the new era, so as to achieve the optimal educational and teaching results.

4.3. Clarify the multifaceted nature of physical education teaching methods

Many methods of teaching are formed by a cycle of teacher teaching and student learning, and in order to achieve the purpose of teaching learn to utilize modern methods of teaching physical education. For example, teachers and students participate in activities together, and this form of organization can motivate teachers to teach content effectively, but also help students to improve their observation skills

and concentrate on listening and learning. Teachers in physical education should make use of the comprehensive teaching methods and effective learning of students to set up teaching methods, the real physical education teacher's own teaching methods effectively applied to the actual learning of students.

5. Conclusion

Effective teaching method is the primary issue of carrying out the classroom, and it is crucial for a series of sports activities such as the implementation of the curriculum of college physical education teaching. On the basis of clarifying the influencing factors of physical education teachers' teaching methods, we set the independent variables and dependent variables, and construct the corresponding multiple linear regression model. Using the model of this paper to carry out in-depth exploration of college physical education teaching, aiming to provide theoretical support for the optimization path of college physical education teaching. Its research results are:

(1) The questionnaire designed in this paper meets the research standard, its reliability coefficient is greater than 0.85, and the correlation coefficient of structural validity is 0.239-0.787, which ensures the availability of the research data and provides data support for the subsequent research work.

(2) The regression coefficients of the four independent variables and the dependent variable are 0.119, 0.103, 0.105, 0.132, and have a significant positive influence at the level of 0.05, while the explanatory power of the independent variable on the dependent variable is 74.9%, demonstrating the mechanism of the role of the teacher's teaching method innovation among the influencing factors. In addition in order to improve the level of physical education teaching in colleges and universities, the corresponding optimization path is proposed.

Funding

This research was supported by the research project for higher education in the "14th Five Year Plan" of Guangdong Higher Education Association in 2023: "Research on Enhancing the Educational and Teaching Abilities of Physical Education Teachers in Private Universities under the Background of Digital Education" (23GYB87).

Add another fund project

This study was supported by the Guangdong Provincial "Ministry of Education Industry University Cooperation Collaborative Education Project" and "Research on College Physical Education Teaching Practice Based on Virtual Reality Technology Assistance" (Project No. 2505284922).

References

1. Liu, T., Wilczyńska, D., Lipowski, M., & Zhao, Z. (2021). Optimization of a sports activity development model using artificial intelligence under new curriculum reform. International Journal of Environmental Research and Public Health, 18(17), 9049.
2. Liu, S., Zhang, J., Zhang, Y., & Zhu, R. (2020). A wearable motion capture device able to detect dynamic motion of human limbs. Nature communications, 11(1), 5615.
3. Li, X., Fan, D., Feng, J., Lei, Y., Cheng, C., & Li, X. (2025). Systematic review of motion capture in virtual reality: Enhancing the precision of sports training. Journal of Ambient Intelligence and Smart Environments, 17(1), 5-27.
4. Adam, T. (2019). Digital neocolonialism and massive open online courses (MOOCs): colonial pasts and neoliberal futures. Learning, Media and Technology, 44(3), 365-380.
5. Saragih, M. J., Cristanto, R. M. R. Y., Effendi, Y., & Zamzami, E. M. (2020, June). Application of blended learning supporting digital education 4.0. In Journal of Physics: Conference Series (Vol. 1566, No. 1, p. 012044). IOP Publishing.
6. Xuemei, W. (2025). DIGITAL DISCOURSE IN ENGLISH LANGUAGE TEACHING: EXPLORING MAN-MACHINE COLLABORATION MODELS THROUGH SYMBIOSIS THEORY. Journal of Pragmatics and Discourse Research, 5(2), 145-162.
7. Almulla, M. A. (2022). Using digital technologies for testing online teaching skills and competencies during the COVID-19 pandemic. Sustainability, 14(9), 5455.
8. Gillet, D., Vonèche-Cardia, I., Farah, J. C., Hoang, K. L. P., & Rodríguez-Triana, M. J. (2022, March). Integrated model for comprehensive digital education platforms. In 2022 IEEE Global Engineering Education Conference (EDUCON) (pp. 1587-1593). IEEE.
9. Khmelnitska, I., Lisenchuk, G., Bogatyrev, K., Zhigadlo, G., Krupenya, S., & Zaloylo, V. (2024). Features of modern motion capture systems. Sport Science Spectrum, 2, 14-19.
10. Tsampounaris, G., El Raheb, K., Katifori, V., & Ioannidis, Y. (2016, November). Exploring visualizations in real-time motion capture for dance education. In Proceedings of the 20th Pan-Hellenic Conference on Informatics (pp. 1-6).
11. Whalley, B., France, D., Park, J., Mauchline, A., & Welsh, K. (2021). Towards flexible personalized learning and the future educational system in the fourth industrial revolution in the wake of Covid-19. Higher Education Pedagogies, 6(1), 79-99.

12. Cheung, S. K., Kwok, L. F., Phusavat, K., & Yang, H. H. (2021). Shaping the future learning environments with smart elements: challenges and opportunities. International Journal of Educational Technology in Higher Education, 18(1), 16.
13. Chang, D. H., Lin, M. P. C., Hajian, S., & Wang, Q. Q. (2023). Educational design principles of using AI chatbot that supports self-regulated learning in education: Goal setting, feedback, and personalization. Sustainability, 15(17), 12921.
14. Zhang, D. J., Allon, G., & Van Mieghem, J. A. (2017). Does social interaction improve learning outcomes? Evidence from field experiments on massive open online courses. Manufacturing & Service Operations Management, 19(3), 347-367.
15. Libre, N. A. (2021). A discussion platform for enhancing students interaction in the online education. Journal of Online Engineering Education, 12(2), 07-12.
16. Andel, S. A., de Vreede, T., Spector, P. E., Padmanabhan, B., Singh, V. K., & De Vreede, G. J. (2020). Do social features help in video-centric online learning platforms? A social presence perspective. Computers in Human Behavior, 113, 106505.
17. Han, J., Zhao, J., Yue, Y., & Che, X. (2024). Edge Computing-based Video Action Recognition Method and Its Application in Online Physical Education Teaching. IEEE Access.
18. Zhier, L. (2016). Research on the physical education teaching system based on 3D human motion capture. International Journal of Signal Processing, Image Processing and Pattern Recognition, 9(12), 61-70.
19. Chen, Z., Song, X., Zhang, Y., Wei, B., Liu, Y., Zhao, Y., ... & Shu, S. (2022). Intelligent Recognition of Physical Education Teachers' Behaviors Using Kinect Sensors and Machine Learning. Sensors & Materials, 34.
20. Ding, X., Peng, W., & Yi, X. (2022). Evaluation of physical education teaching effect based on action skill recognition. Computational Intelligence and Neuroscience, 2022(1), 9489704.
21. Lin, J., & Song, J. (2023). Design of motion capture system in physical education teaching based on machine vision. Soft Computing, 1-10.
22. Lu, Y., & Long, H. (2025). Motion Capture Algorithm for Students' Physical Activity Recognition in Physical Education Curriculum. Journal of Artificial Intelligence and Technology, 5, 1-9.
23. Ruiz-Rojas, L. I., Acosta-Vargas, P., De-Moreta-Llovet, J., & Gonzalez-Rodriguez, M. (2023). Empowering education with generative artificial intelligence tools: Approach with an instructional design matrix. Sustainability, 15(15), 11524.
24. Wang, H., Zheng, D., Wang, M., Ji, H., Han, J., Wang, Y., ... & Qiao, J. (2025). Artificial Intelligence–Powered Training Database for Clinical Thinking: App Development Study. JMIR Formative Research, 9(1), e58426.
25. Huang, C. H., Chin, S. L., Hsin, L. H., Hung, J. C., & Yu, Y. P. (2011). A web-based e-learning platform for physical education. Journal of Networks, 6(5), 721.
26. Zhou, B. (2016). Smart classroom and multimedia network teaching platform application in college physical education teaching. International Journal of Smart Home, 10(10), 145-156.
27. Da-Wei, C., Chao, L., Shun, W., Xun-Ling, W., & Wen-fang, W. (2018). Research and application of multimedia digital platform in the teaching of college physical education course. Journal of Intelligent & Fuzzy Systems, 34(2), 893-901.
28. Aksir, M. I., Hasyim, H., & Syafruddin, M. A. (2024). Utilization of Digital Platform-Based Learning Media: Interest and Learning Achievement in Physical Education at State Elementary School. ETDC: Indonesian Journal of Research and Educational Review, 3(4), 65-74.
29. Li, G., & Liu, J. (2024). Improving physical education through innovative multimedia learning platform and data-driven instruction: G. Li, J. Liu. Soft Computing, 28(2), 1567-1584.
30. Luo, Q. (2023). Practical Analysis of Digital Technology in an Electronic Education Platform in PE Training. International Journal of Emerging Technologies in Learning (iJET), 18(22), 59-72.
31. Wu, D., Guo, Z., Wang, Y., & Li, Z. (2024). Auxiliary analysis of digital platform using internet of things technology in physical education teaching. Education and Information Technologies, 29(12), 15855-15874.
32. Palao, J. M., Hastie, P. A., Cruz, P. G., & Ortega, E. (2015). The impact of video technology on student performance in physical education. Technology, Pedagogy and Education, 24(1), 51-63.
33. Koekoek, J., Van Der Mars, H., van der Kamp, J., Walinga, W., & van Hilvoorde, I. (2018). Aligning digital video technology with game pedagogy in physical education. Journal of Physical Education, Recreation & Dance, 89(1), 12-22.
34. Zulkifli, A. F., & Danis, A. (2022). Technology in physical education: Using movement analysis application to improve feedback on sports skills among undergraduate physical education students. Social Sciences & Humanities Open, 6(1), 100350.
35. van Hilvoorde, I., & Koekoek, J. (2018). Digital technologies: A challenge for physical education. In Changes in childhood and adolescence: current challenges for physical education: keynotes, invited symposia and selected contributions of the 12th FIEP European Congress (pp. 54-63).
36. Martínez-Rico, G., Alberola-Albors, M., Pérez-Campos, C., & González-García, R. J. (2021). Physical education teachers' perceived digital competences: Are they prepared for the challenges of the new digital age?. Sustainability, 14(1), 321.
37. Moustakas, L., & Robrade, D. (2022). The challenges and realities of e-learning during COVID-19: The case of university sport and physical education. Challenges, 13(1), 9.
38. Hui Yang. (2024). A study on the influence of soccer culture on physical education in China's universities based on linear regression analysis. Applied Mathematics and Nonlinear Sciences,9(1).

39. Jin Chen. (2024). Linear regression analysis of the correlation between students' physical education performance and academic achievement in the context of smart physical education in colleges and universities. Applied Mathematics and Nonlinear Sciences,9(1).