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Article

Research on the Path of Teachers' Professionalism Improvement Based on Principal Component Analysis under the Framework of Basic Theory of Education

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Abstract: Teachers' professional competence levels influence students' learning quality. This paper constructs an evaluation index system for professional competence within the framework of basic educational theory and systematically analyzes the requirements for the development of teachers' professional competence. Principal component analysis (PCA) is used to reduce the dimensionality of the evaluation data. For some non-linear data, kernel principal component analysis (KPCA) is introduced to complete the principal component calculation. By calculating the feature vector load matrix and T^2 statistic, the principal component factors are extracted, and teachers' professional competence is ranked. The study shows that the sum of the variance contribution rates of the first four principal components is 94.247%. The four principal components are defined as practical professional competence, innovative professional competence, ethical professional competence, and information professional competence. The comprehensive principal component scores of the eight teachers range from [0.015, 0.064]. Based on the principal component analysis results, four pathways for enhancing professional competence were proposed.

Keywords: PCA; KPCA; teacher professional competence; data dimensionality reduction; load calculation

1. Introduction

Teaching is a unique profession, distinguished by the specialized nature of its work in educating and nurturing students [1]. The primary focus of teachers' labor is the younger generation, whose growth and development follow their own inherent patterns [2]. The complexity of individual student development means that teaching is much more complex than other types of work. Secondly, teaching is a highly creative profession that requires creative efforts to nurture talent in ways that are tailored to the individual, the situation, and the environment [3-5]. In addition, teachers' work serves as a model, and they must use their knowledge and conduct to influence students, setting an example and leading by example [6]. Therefore, the professional qualities required of teachers must be richer in content and more diverse in nature than those required of other professions.

The academic community has established a relatively authoritative definition of teacher professional competence. Literature [7] defines teacher professional competence as four dimensions: knowledge level, professional beliefs, teaching motivation, and self-regulation ability. Research has found that teacher professional competence has a positive impact on students' learning outcomes. Literature [8] emphasizes the importance of qualities such as self-education, caution, understanding student characteristics, generosity, and loyalty, which help teachers achieve a high level of proficiency in guiding and mentoring students. Literature [9] assessed the professional competence of medical teachers at Kerman Shah Medical University from the students' perspective, finding that these teachers scored above average in professional competence. Literature [10] argues that teachers' responsibilities include fulfilling moral and professional obligations in teaching, guiding, and educating students, and adhering to specific standards. Teacher professional competence can help teachers engage in self-reflection, enhance moral



standards, and improve professional competence.

Currently, most universities still lack distinctive “dual-qualified” teacher training models, standardized management methods, and systematic, long-term training mechanisms [11]. University teachers generally face the reality of limited training opportunities, which hinders their ability to learn and absorb new technologies, knowledge, and concepts, and is detrimental to the development of the teaching staff, as well as the improvement of teaching quality and the development of the institution [12-13]. Another issue faced by vocational college teachers is the lack of practical opportunities. Teachers who take up positions in enterprises or public institutions for on-the-job training lack policy support and benefits guarantees, and some enterprises are unwilling to undertake the task of training vocational college teachers [14]. The aforementioned issues all restrict the improvement of teachers' professional competence and block the channels for their professional development.

This paper establishes criteria for designing an indicator system that combines scientific rigor with practicality, based on the multidimensional requirements for teachers' professional competence as outlined in basic educational theory. Using these criteria, an evaluation indicator system for teachers' professional competence is constructed, comprising four primary indicators and eight secondary indicators. To address issues of indicator redundancy and nonlinear limitations, a dual-path analysis framework combining PCA linear dimensionality reduction and KPCA nonlinear mapping is proposed. This framework addresses the multicollinearity issues among professional competence indicators, enabling the transformation of high-dimensional data into low-dimensional principal component factors, thereby enhancing the interpretability of evaluation results. By integrating teacher evaluation sample data with principal component loadings, the framework analyzes teacher professional competence levels and proposes corresponding improvement pathways.

2. Evaluation indicator system construction and data analysis

2.1. Construction of a Teacher Professional Competence Evaluation Index System

2.1.1 Principles for Constructing an Evaluation Indicator System

1) Principle of Scientificity

The construction of an evaluation indicator system must be guided by scientific theory and designed using methods that are flexible and appropriate for the evaluation object. The scientificity of the teacher professional competence evaluation indicator system is primarily reflected in the following aspects: the selected evaluation indicators can effectively reflect various issues in the process of improving teacher professional competence, and the evaluation work is conducted based on actual data regarding teacher professional competence.

2) Principle of Operability

Generally speaking, an evaluation indicator system must not only be applicable to internal and external evaluations but also to peer evaluations. The teacher professional competence evaluation indicator system should cover horizontal comparison content such as teacher development goals and achievements, and it should also be capable of conducting vertical comparisons with the development status of teacher professional competence from the previous stage. Based on societal requirements for teacher professional competence, these requirements should be translated into measurable evaluation indicators.

3) Principle of Combining Quantitative and Qualitative Evaluation

Qualitative evaluation involves describing evaluation objects using language and text, relying on past experience to subjectively analyze their characteristics and patterns of change; quantitative evaluation is a method of evaluation using mathematical language, which employs mathematical modeling to analyze the quantitative relationships and characteristic changes of evaluation objects. By combining qualitative and quantitative approaches, the comprehensiveness of evaluations and the validity of results can be significantly enhanced. For teacher professional competence, evaluation should be conducted based on qualitative analysis, using quantitative assessment standards as a reference.

2.1.2. Evaluation Indicator System Construction

Table 1 shows the teacher professional competence evaluation index system that has been constructed. It includes four first-level indicators—practical competence, innovative competence, information competence, and moral competence—and eight second-level indicators.

The teacher professional competence evaluation index system consists of three levels: evaluation objectives, evaluation dimensions, and evaluation factors.

1) Evaluation objectives

The objective of constructing the teacher professional competence evaluation index system is to

accelerate the development of teacher professional competence evaluation standards, promote the comprehensive development of teachers and educational equity, and improve the quality of teacher education.

2) Evaluation Dimensions

The teacher professional competence evaluation indicator system covers two domains: subject-specific domains and quality domains. The indicators within these two domains are sufficient to assess the extent to which teachers demonstrate their professional qualities in educational teaching and social interactions. The “subject-specific domain” is the core content of teacher professional competence evaluation and forms the foundation of the evaluation indicator system, directly reflecting teachers' teaching capabilities. Among these, “innovative competence” is one of the key metrics for evaluating teachers' professional competence and an essential quality required for teachers to develop diverse teaching activities; “information literacy” is an extension of teachers' professional competence and an important standard reflecting their level of modern smart teaching, demonstrating their ability to deeply integrate information technology with teaching content. The “character domain” emphasizes teachers' sense of responsibility and social responsibility as educators.

3) Evaluation Factors

The evaluation factors of the teacher professional competence evaluation indicator system, i.e., the secondary indicators, are further refinements of the primary indicators. The “new technology acquisition and application ability” in “practical competence” refers to teachers' understanding and application of new technologies and knowledge in the educational process. The “actual problem-solving ability” refers to teachers' ability to identify and resolve issues using theoretical knowledge and practical methods, which is one of the primary objectives of education and teaching. The “innovation literacy” category includes innovative thinking ability, which is the foundation for teachers to form new thinking and create new content through knowledge transfer, and also a prerequisite for cultivating students' creative thinking and innovative abilities. Practical innovation ability is the further application of innovative thinking, reflecting the application level of diverse educational practices. The “information literacy” category includes subject-specific information literacy, which refers to teachers' ability to design subject-specific teaching plans and diverse teaching activities using information processing tools. Research information literacy is an important component of teachers' professional development and reflects the level of research activities and the integration of science and education. The emotions, attitudes, and values within “moral literacy” are a comprehensive reflection of teachers' professional literacy and also represent society's practical requirements for teachers to possess positive emotional concepts, correct attitudes toward life, and good moral qualities. Healthy aesthetic tastes are a proactive value-oriented activity and represent an integrated evaluation of teachers' ability to discover and create beauty.

Table 1 Evaluation Index System for teachers' professional qualities

Field	First-level indicator	Secondary indicator
Disciplinary field	Practical literacy (A1)	Ability to acquire and apply new technologies (B1)
		Practical problem-solving ability (B2)
	Innovation literacy (A2)	Innovative thinking ability (B3)
		Practical innovation ability (B4)
	Information literacy (A3)	Subject information literacy (B5)
		Scientific research information

		literacy (B6)
Quality field	Moral quality (A4)	Emotions, attitudes and values (B7)
		Healthy aesthetic taste (B8)

2.2. Data Analysis of Professional Competency Evaluation

2.2.1. Teacher Professional Competency Evaluation Data

Each of the aforementioned indicators is divided into five levels: excellent, good, average, poor, and very poor. Eight teachers were selected as the research subjects for this study, with their professional competence scores serving as the data. After consulting with supervisory experts, the five evaluation categories (excellent, good, average, poor, and very poor) were each mapped to a specific range within the 0–100 scale. Normal random numbers were then used to quantify each given range, resulting in eight sets of evaluation data. On the other hand, since the 8 evaluation forms contained evaluation data from different experts on the same teacher, the scores for the same teacher were averaged, resulting in the evaluation data from supervision experts on the 8 teachers across the 8 indicators. Figure 1 shows the specific details of the teachers' professional competence evaluation data. The evaluation scores for the 8 teachers generally ranged between 70 and 90 points, with some indicators scoring above 90 points, and only a few indicators scoring below 70 points. The teacher score data is relatively diverse, meeting the requirements for data analysis.

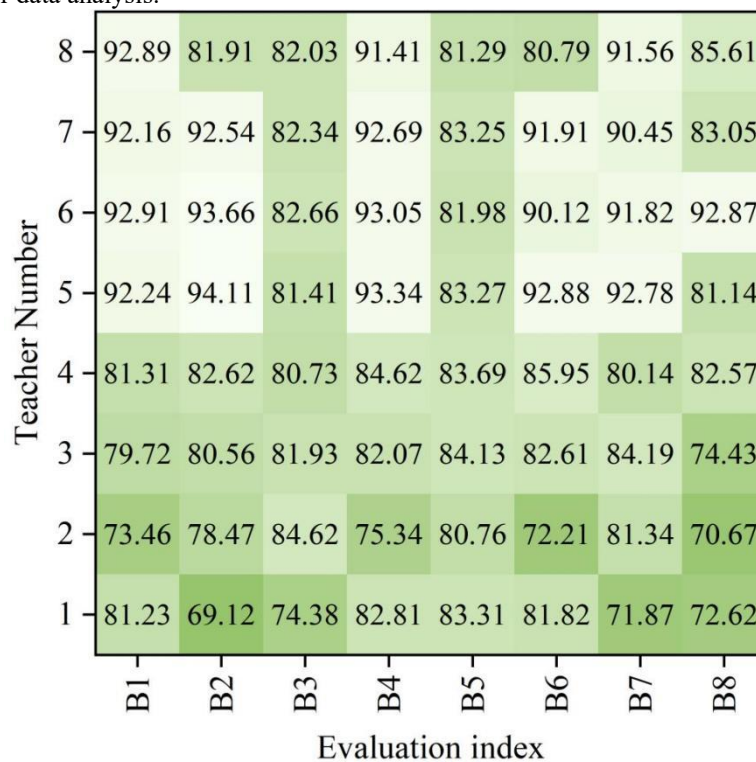


Figure 1. Evaluation data of teachers' professional qualities.

2.2.2. Correlation Analysis

As can be seen from Figure 1, some of the eight indicators show a clear correlation. Therefore, a pairwise correlation analysis was conducted on the data in Figure 1 at a significance level of $\alpha = 0.05$. Table 2 presents the results of the statistical analysis of data correlations. Most indicators exhibit significant correlations at the 0.01 or 0.05 significance levels, indicating that these 8 indicators are not independently derived and could be replaced by a smaller set of independent indicators. To this end, principal component analysis can be applied to the evaluation data to extract more effective independent

indicators.

Table 2. Statistical analysis results of data correlation.

		B1	B2	B3	B4	B5	B6	B7	B8
B1	Corr.	1	0.436 **	0.124 *	0.657 **	0.482 **	0.471	-0.102	0.294 **
	Sig.	-	0.001	0.023	0.003	0.001	0.259	0.791	0.002
B2	Corr.	0.436 **	1	0.654 **	0.325 *	0.531 *	0.204	0.024	0.367 **
	Sig.	0.001	-	0.004	0.011	0.002	0.215	0.531	0.002
B3	Corr.	0.124 *	0.654 **	1	0.352 **	0.312	0.203	0.157	0.251 *
	Sig.	0.023	0.004	-	0.001	0.583	0.162	0.026	0.009
B4	Corr.	0.657 **	0.325 *	0.352 **	1	0.321 **	0.024	0.116	0.301 *
	Sig.	0.003	0.011	0.001	-	0.004	0.613	0.325	0.008
B5	Corr.	0.482 **	0.531 *	0.312	0.321 **	1	0.027	-0.089	0.261 *
	Sig.	0.001	0.002	0.583	0.004	-	0.163	0.517	0.016
B6	Corr.	0.471	0.204	0.203	0.024	0.027	1	0.127 *	-0.017
	Sig.	0.259	0.215	0.162	0.613	0.163	-	0.021	0.513
B7	Corr.	-0.102	0.024	0.157	0.116	-0.089	0.127 *	1	0.178
	Sig.	0.791	0.531	0.026	0.325	0.517	0.021	-	0.042
B8	Corr.	0.294 **	0.367 **	0.251 *	0.301 *	0.261 *	-0.017	0.178	1
	Sig.	0.002	0.002	0.009	0.008	0.016	0.513	0.042	-

Note: ** indicates a significant correlation at the 0.1 level (bilateral), and * indicates a significant correlation at the 0.05 level (bilateral).

3. Teacher Professional Competence Based on Principal Component Analysis

3.1. Description of Principal Component Analysis Method

3.1.1. Principal component analysis method

Principal Component Analysis (PCA) can be used for dimensionality reduction of high-dimensional

data in teacher professional competence evaluation. This method achieves dimensionality reduction by identifying a set of linearly independent new variables to replace the original variables, thereby improving the efficiency of data processing and analysis, and providing more precise monitoring and diagnostic tools for professional competence levels. Through PCA, not only can the correlations between the original variables be effectively eliminated, but the data dimension can also be significantly reduced, and key features can be extracted, thereby providing a clearer and more advantageous data representation form for subsequent analysis and modeling. The following is a brief introduction to the PCA calculation process.

Before performing PCA, it is usually necessary to standardize the data to avoid the effects of different units of measurement. For a dataset $X = [x_1, x_2, \dots, x_n] \in R^{n \times m}$ with n dimensions and m sample points, Z-score normalization is performed. The formula is given by Equation (1), where x_i is the original data, and μ and σ are the mean and standard deviation of the original data, respectively.

$$x_i^* = \frac{x_i - \mu}{\sigma} \quad (1)$$

The main trend of the data is revealed by maximizing the projection variance on the maximum principal component. For this purpose, an objective function (2) is defined, where p_1 is the load vector representing the first principal component direction.

$$\max_p p_1^T X^T X p_1 \quad (2)$$

$$s.t \quad \|p_1\| = 1 \quad (3)$$

To solve this optimization problem, the Lagrange multiplier method is used, as shown in Equation (4):

$$\lambda p_1 = X^T X p_1 \quad (4)$$

From the above equation, we can see that the load vector p_1 is the eigenvector obtained after performing eigenvalue decomposition on $X^T X$, and λ is the corresponding eigenvalue. By multiplying the original data X by the load vector p_1 on the right, we obtain the score vector t_1 . t_1 represents the projection of the data on the first principal component, and its calculation method is as shown in equation (5).

$$t_1 = X p_1 \quad (5)$$

The residual matrix can be obtained by subtracting the projection matrix formed by the score vector t and the load vector p from the original data matrix X , as shown in Equation (6):

$$X_{residual} = X - t_1 p_1^T \quad (6)$$

To obtain other principal component directions, the remaining matrix can be substituted into the objective function, and a series of load vectors and score vectors p_i and t_i can be calculated in sequence, as follows:

$$\|t_i\| > \|t_{i+1}\| \quad (7)$$

The changes in the corresponding original data on the new load vector gradually decrease. If the first n score vectors already contain most of the information in the original space, the remaining score vectors can be ignored.

The calculated loadings and scores are organized into the loading matrix $P = [p_1, p_2, \dots, p_n]$ and the score matrix $T = [t_1, t_2, \dots, t_n]$, where n denotes the number of principal components containing the majority of the information. The original data can then be decomposed along the new principal component directions as follows:

$$X = t_1 p_1^T + t_2 p_2^T + \dots + t_n p_n^T + E = TP^T + E \quad (8)$$

Where E is the residual space, which is typically considered to consist mainly of noise.

When performing PCA, determining the number of principal components is a critical step, as it directly affects the effectiveness of data dimensionality reduction and the interpretability of the model. The cumulative variance contribution rate (CPV) assesses the extent to which the model explains the variability of the original data by accumulating the variance contribution rates of each principal component. Due to its simplicity and practicality, it has become the mainstream method for calculating the number of principal components. When the cumulative variance contribution rate reaches a predefined threshold, it can be considered that the selected principal components have captured the main changes and structural information in the data. The calculation method for the cumulative variance contribution rate is shown in Equation (9).

$$CPV = \frac{\sum_{j=1}^n \lambda_j}{\sum_{j=1}^t \lambda_j} \quad (9)$$

In the field of literacy assessment, PCA-based assessment methods typically use the T^2 statistic and corresponding threshold values to establish assessment models. The T^2 statistic is a statistical method used for multivariate literacy assessment, similar to the sigma level in univariate analysis. The T^2 statistic is used to assess whether a multivariate data point is far from the center of literacy, thereby determining whether the process is in good condition. The formula for calculating the T^2 statistic is as follows:

$$T^2 = x^T P (\Lambda^{-1}) P^T x \quad (10)$$

where Λ is the covariance matrix. The calculation of the T^2 control limit typically depends on the desired sigma level and assumes that the data are normally distributed. For a given sigma level, the T^2 control limit UCL (upper control limit) can be expressed as:

$$UCL = \frac{k(n-1)(n+1)}{n(k, n-k)} F_\alpha(k, n-k) \quad (11)$$

Among them, $F_\alpha(k, n-k)$ denotes the upper bound of the F distribution with degrees of freedom k and $n-k$ and confidence level α .

3.1.2. Nuclear principal component analysis

Common dimension reduction techniques include principal component analysis (PCA), linear discriminant analysis (LDA), and multidimensional scaling (MDS). The essence of these dimension reduction methods is to map high-dimensional data to a low-dimensional subspace through linear transformation, thereby achieving dimension reduction. While reducing the dimension of the data, these methods strive to retain the key features of the original data. The advantages of these methods are that they simplify the calculation steps and provide a clear approach. However, if the original data consists of feature combinations without obvious linear patterns, it is difficult to apply linear dimensionality reduction methods. For example, some of the evaluation data collected earlier exhibit non-linear characteristics. In such cases, one may consider using kernel principal component analysis (KPCA), a method suitable for dimensionality reduction analysis of non-linear data.

KPCA serves as a bridge between linear and non-linear approaches. Its fundamental analytical principle involves mapping data from the original high-dimensional space to a higher-dimensional feature space, enabling the data to be linearly separated in the new feature space. The key to KPCA lies in using kernel techniques to transform non-linear relationships in the original feature space into linear relationships in the high-dimensional feature space. KPCA calculates the principal components of the data in the new feature space to achieve the goal of dimensionality reduction.

We can assume that there is a data point q in the original data sample space, which exists in a high-dimensional space N . This data point q is mapped to a high-dimensional space N through a mapping function $q \rightarrow \varphi(q) \in N$.

Two points q_i, q_j are randomly selected from the original data space and mapped to the feature space of the high-dimensional space N . We use the dot product algorithm to analyze $\varphi(q_i)\varphi(q_j)$.

Here, we can define $y(q_i, q_j) = \varphi(q_i)\varphi(q_j)$ as the kernel function.

The covariance matrix in the N -dimensional space can be represented by A , denoted as:

$$A = \frac{1}{x} \sum_{i=1}^x (\varphi_i - s)(\varphi_i - s)^K \quad (12)$$

Let us denote the eigenvalue corresponding to a random eigenvector b in the covariance matrix A by λ . Then we obtain:

$$Ab = \lambda b \quad (13)$$

However, since the eigenvector of b is derived from $(\varphi_i - s)$ in the eigen space, it can also be expressed as:

$$b = \sum_i \beta_i (\varphi_i - s) \quad (14)$$

Both sides of the above equation are in N -dimensional space and are generated by $\{\varphi_i - s\}$, so they can represent x equations.

$$(\varphi_i - s)^K Ab = \lambda (\varphi_i - s)^K b \quad (15)$$

Now let's deal with the kernel matrix. Let the kernel matrix be T , where the elements $T_{i,j} = \varphi_i \varphi_j$, $i, j = 1, 2, 3, \dots, x$. We can also use the known kernel function to calculate the dot product in the covariance matrix A , i.e., $\varphi_i \varphi_j = y(q_i, q_j)$. If we want to perform factor analysis at this point, we need to center the kernel matrix, which can be denoted as T^A . The following equation expresses this:

$$T^A = ETE \quad (16)$$

In the above equation, E is a new element, and the formula is:

$$E = 1.0 - \frac{1}{x} ww' \quad (17)$$

where w is an x -dimensional column vector with each element equal to 1.0. From this, we can deduce that the above equation $(\varphi_i - s)^K Ab = \lambda (\varphi_i - s)^K b$ can be converted to the following equation:

$$T^A T^A \beta = \bar{\lambda} T^A \beta \quad (18)$$

In the above equation, $\bar{\lambda} = x\lambda$, and $\beta \in R^x$. We can simplify it further:

$$T^A \beta = \lambda \beta \quad (19)$$

At this point, it is not difficult to see that $T^A T^A \beta = \bar{\lambda} T^A \beta$ and $T^A \beta = \lambda \beta$ are likely to have common solutions, and that the solution to $T^A T^A \beta = \bar{\lambda} T^A \beta$ can be expressed in another way. By supplementing the solution β of $T^A \beta = \lambda \beta$ with a vector μ that satisfies the orthogonality condition with β , it can be expressed. And it satisfies:

$$\sum_i \varphi_i \mu_i = 0.0 \quad (20)$$

Therefore, μ does not actually change $b = \sum_i \beta_i (\varphi_i - s)$. So, when calculating b , we can use decomposition centralization and T^A to solve it. During the solution process, the following condition must be satisfied: $b^* b = 1.0 = \bar{\lambda} \beta \cdot \beta$, so β can be modeled as $\frac{1}{\sqrt{\bar{\lambda}}}$.

In the final step, we need to analyze the principal components in the sample data points. Here, the principal components are still nonlinear. The principal components of the training set vector q_y are calculated as follows:

$$\varphi(q_y) - s \cdot b = \lambda \beta_y \quad (21)$$

The principal component calculation method for test vector q is as follows:

$$\begin{aligned} \varphi(q_y) - s \cdot b = & \sum_i \beta_i y(q, q_j) - \frac{1}{x} \sum_{i,j} \beta_i y(q, q_j) \\ & - \frac{1}{x} \sum_{i,j} \beta_i y(q_i, q_j) + \frac{1}{x^2} \sum_{i,j,n} \beta_i y(q_i, q_u) \end{aligned} \quad (22)$$

3.2. Teacher Professional Competence Level Based on Principal Component Analysis

3.2.1. Calculation of indicator data

Based on experts' evaluations of the professional competence levels of these 8 teachers, principal component analysis was used to analyze and study their professional competence levels. The SPASS analysis software was used to analyze and process the raw scoring data, yielding the eigenvalues, variance contribution rates, and cumulative variance contribution rates for the 8 indicators. Table 3 shows the results of the indicator data calculations. Figure 2 shows the Pareto distribution of the percentage shares of each principal component. Generally speaking, as long as the cumulative variance contribution rate of the first N principal components reaches 90%, it can be concluded that the first N principal components essentially encompass all the information of the established indicator system. In other words, the new indicator system composed of the first N principal components can fully represent the original indicator system to conduct a comprehensive evaluation of the evaluation subject. As shown in Table 3 and Figure 2, the sum of the variance contribution rates of the first 4 principal components has reached 94.247%, which basically meets the relevant requirements. Therefore, the first 4 principal components can be used as indicators for evaluating teachers' professional competence, and they are named F1, F2, F3, and F4.

Table 3. Total Variance Explained.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative (%)	Total	% of Variance	Cumulative (%)
1	3.864	31.850	31.850	3.864	31.850	31.850
2	3.017	24.868	56.718	3.017	24.868	56.718
3	2.433	20.054	76.772	2.433	20.054	76.772
4	2.120	17.475	94.247	2.120	17.475	94.247
5	0.297	2.448	96.695	-		
6	0.268	2.209	98.904			
7	0.102	0.841	99.745			
8	0.031	0.255	100.000			

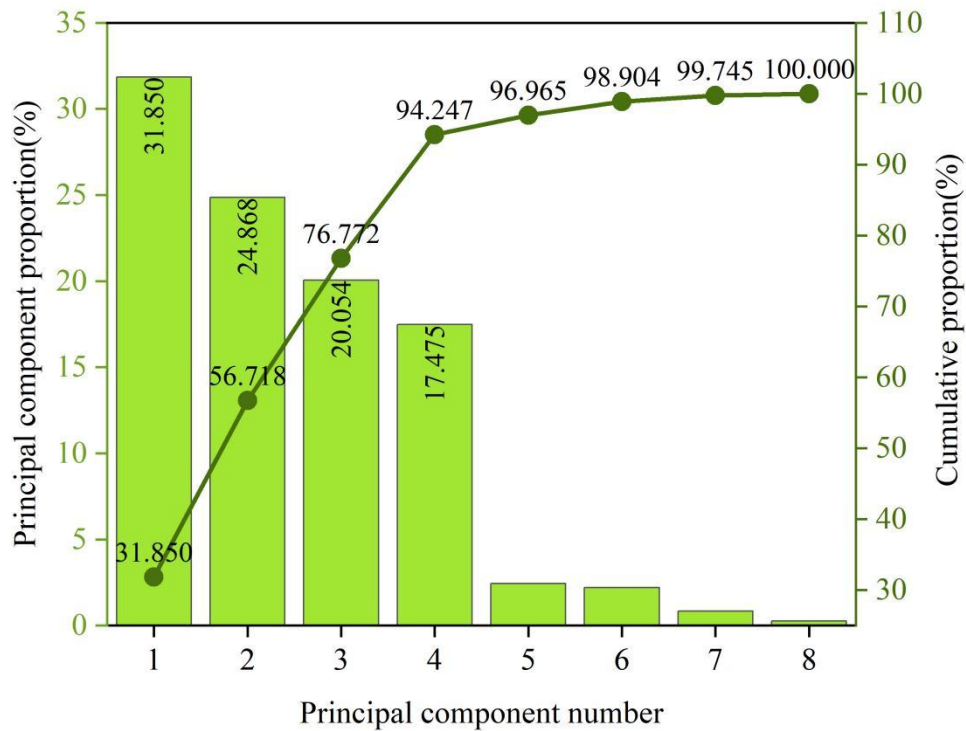


Figure 2. Pareto as the percentage of each principal component.

3.2.2. Determination of principal component loadings

After identifying the principal components, the loadings of each indicator on the four principal components were further calculated. Table 4 shows the results of the principal component loading calculations. F1 has high loadings of 0.551 and 0.575 on new technology acquisition and application ability (B1) and practical problem-solving ability (B2), meaning that principal component F1 can well explain these two variables. Therefore, principal component F1 can be interpreted as practical professional competence. Similarly, principal component F2 can be interpreted as innovative professional competence; F3 as ethical professional competence; and F4 as information professional competence.

Table 4. Principal component load.

Indicator	F1	F2	F3	F4
B1	0.551	0.109	0.102	0.123
B2	0.575	0.113	0.174	0.105
B3	0.193	0.558	0.183	0.107
B4	0.182	0.552	0.118	0.185
B5	0.175	0.176	0.125	0.546
B6	0.163	0.124	0.137	0.529
B7	0.154	0.138	0.561	0.176
B8	0.152	0.145	0.524	0.139

3.2.3. Professional competence scores and rankings for each teacher

By transforming the raw evaluation scores of the 8 teachers into the principal component space, we obtain the scores for each principal component. By multiplying each principal component score by its corresponding contribution rate and then summing them up with weights, we can calculate the

comprehensive scores for each teacher's professional competence. Table 5 shows the professional competence scores and rankings of the 8 teachers. The average principal component composite scores for the 8 teachers are: 0.015, 0.023, 0.027, 0.032, 0.045, 0.064, 0.051, and 0.039. The teacher with the highest professional competence level is Teacher 6, with a composite score of 0.064 across the 4 principal components; the lowest is Teacher 1, with a composite score of 0.015.

Table 5. The professional quality scores and ranking results of 8 teachers.

Teacher Number	Score				Comprehensive score	Ranking
	F1	F2	F3	F4		
1	0.007	0.012	0.018	0.020	0.015	8
2	0.018	0.023	0.026	0.025	0.023	7
3	0.025	0.028	0.027	0.028	0.027	6
4	0.031	0.034	0.030	0.032	0.032	5
5	0.042	0.049	0.043	0.044	0.045	3
6	0.065	0.067	0.060	0.063	0.064	1
7	0.053	0.052	0.049	0.050	0.051	2
8	0.036	0.041	0.036	0.042	0.039	4

4. Pathways for improving teacher professional competence based on principal component analysis

Based on the four main components of teacher professional competence—practical professional competence, innovative professional competence, ethical professional competence, and information professional competence—the following recommendations are made for enhancing teacher professional competence:

1) Utilize school resources to improve practical skills. Schools provide teachers with abundant teaching practice resources, such as departmental activities, open class observations, and teaching seminars. To enhance teaching practice competence, teachers should actively participate in these activities, exchange teaching experiences with peers, learn from others' strengths, and address their own weaknesses. Additionally, teachers should utilize school facilities such as laboratories and libraries to conduct practical teaching activities and enhance students' hands-on skills. Furthermore, teachers should value school-organized professional development courses, study diligently, apply the knowledge gained to teaching, and continuously optimize teaching practices to improve teaching competence.

2) Enhance innovative capabilities and optimize teaching methods. Teachers should cultivate an innovative mindset and actively explore new teaching methods and approaches. For example, they can experiment with innovative teaching models such as project-based learning and group collaboration to stimulate students' interest and initiative in learning. Additionally, teachers can design personalized teaching plans tailored to students' actual circumstances to meet the diverse learning needs of different students. By continuously innovating teaching methods, teachers can improve teaching effectiveness, cultivate students' innovative thinking and practical abilities, and enhance their own innovative capabilities.

3) Uphold the role of teachers and respect behavioral norms. Teachers play an important role in the educational process and should always maintain their proper position, establish correct educational concepts, and improve their moral and professional qualities. Teachers should respect students' personalities, care about their physical and mental health, and treat every student with an equal attitude. At the same time, teachers should strictly adhere to professional ethical norms, remain integrity in teaching, and serve as role models. In daily teaching, teachers should lead by example and set a good example for students through their words and actions. Respecting behavioral norms is a requirement of moral and professional integrity for teachers, as well as a manifestation of responsibility toward students and the education sector.

4) Learn information technology and cultivate information awareness. In today's information age, teachers must master certain information technology knowledge and continuously improve their information professional competence. To this end, teachers can participate in information technology training courses or engage in self-directed learning to master the use of technical tools such as multimedia production and online teaching platforms. Additionally, teachers should cultivate an information-oriented mindset, stay informed about the latest developments and cutting-edge

technologies in the field of education, and integrate information technology deeply into subject-specific teaching to enhance teaching efficiency and quality. Only by continuously improving their information professional competence can teachers better adapt to the evolving demands of modern educational informatization and provide students with higher-quality educational services.

5. Conclusion

This paper constructs an evaluation index system for teachers' professional competence and uses PCA/KPCA methods to extract principal components and evaluate teachers' professional competence. The sum of the variance contribution rates of the first four principal components—practical professional competence, innovative professional competence, ethical professional competence, and information professional competence—reaches 94.247%. The average principal component scores for the eight teachers are as follows: 0.015, 0.023, 0.027, 0.032, 0.045, 0.064, 0.051, and 0.039. Based on the evaluation results, the following recommendations are proposed: Utilize school resources to enhance practical skills; strengthen innovative capabilities and optimize teaching methods; clarify the role of teachers and uphold behavioral norms; and learn information technology to foster information awareness. These four pathways are proposed for enhancing professional competencies. Future research could explore establishing a dynamic weight adjustment mechanism for indicators to enhance the model's adaptability.

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