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Teaching Performance Evaluation in Smart Campus

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ABSTRACT With the rapid development of modern teaching technology, the construction of smart campus has become the focus of modern college education reform. The application of technologies, such as the Internet of Things and big data, plays an important role in improving the teaching environment of colleges and universities, improving the utilization of teaching resources, and the flexibility of education. As an important part of campus activities, teaching performance evaluation scientifically and effectively utilizes teaching information and teacher and student interaction information to evaluate teachers' teaching performance, which helps to motivate teachers' work enthusiasm, improve teaching quality, and enhance school core competitiveness. This paper analyzes the salient features of smart campus from the perspectives of technology, business, and construction mode, and proposes a smart campus architecture model. According to the research content of teaching performance evaluation, the framework model of smart campus education data collection and storage platform is established, which provides a reference model for the construction of smart campus in colleges and universities. The evaluation of teaching performance in smart campus first analyzes the shortcomings of traditional evaluation methods and proposes the necessity of combining teaching performance evaluation with modern technology. Second, six principal components were determined using the PCA algorithm. Then, use the AHP to calculate the weights of each layer of the indicator set, avoiding the decision errors caused by subjective factors. Finally, the gray correlation degree is used to improve the TOPSIS algorithm for multi-objective decision analysis. The evaluation results of the AHP-TOPSIS teaching performance model are consistent with the actual situation. The application of the smart campus education data platform combined with the AHP and the gray correlation improvement TOPSIS algorithm is more targeted to the teacher's teaching performance evaluation and provides a new evaluation method for scientific performance evaluation, and avoid the problem of strong subjectivity of traditional teaching performance evaluation.

INDEX TERMS Smart campus, teaching performance evaluation, educational big Data, analytic hierarchy process, grey correlation degree, TOPSIS algorithm.

I. INTRODUCTION

Under the background of the rapid development of modern technology, the development of educational informatization has become an important part of contemporary education reform, and colleges and universities have gradually attached importance to the construction of smart campuses in colleges and universities. The characteristics of the smart campus include comprehensive environmental awareness, seamless network connection, massive data support, open learning environment and personalized services for teachers and students [1]. In order to adapt to the pace of scientific and technological development, the construction of smart campus has been put forward, and many colleges and universities have begun to try to introduce big data, thereby improving the quality of education services, reducing service costs and improving management efficiency [2].

With the advancement of higher education teaching reform, more people are paying attention to a more scientific, intelligent and effective construction of modern campuses. For the administrative education workers, their pain point is how to improve the teaching level of the school and the quality of the teachers' education. The key issue is how to make the most of the teaching assessment method. Therefore, the requirements for college teachers are further improved. College teachers must not only conscientiously complete daily teaching activities, but also need to make full use of the school's well-established online platform to do real-time communication with students in class. For this task, the full use of Internet of Things technology can greatly reduce the workload of administrative education workers.

With the advancement of higher education teaching reform, the requirements for college teachers have been further improved. College teachers must not only make certain achievements in classroom teaching under the line, but also make full use of the Internet for online teaching. The evaluation of teachers' comprehensive ability has certain reference significance in the teacher's year-end assessment and job title evaluation, and has become an important task of the school personnel department. However, the work of school teachers is characterized by creativity, complexity, and concealed labor results. Therefore, the indicators involved in teacher evaluation are numerous and complex, and the evaluation work has certain difficulties.

Therefore, starting from the wisdom campus teaching data, constructing a set of evaluation indicators and evaluation methods to quantify the teacher network teaching performance has become a key issue to expand the education informationization of China [3]. Wang Chenglin proposed to use the smart campus platform to replace the language descriptive evaluation criteria with the big data quantitative evaluation criteria, and to conduct self-evaluation, student evaluation and teacher mutual evaluation on the platform, which greatly improved the efficiency of performance evaluation [4], [5]. Griff *et al.* evaluated the effectiveness of students using the online platform to study two courses in terms of test scores, class performance, and homework performance [6]. In addition, Reeves also proposed three evaluation portfolio strategies for online learning environments: cognitive assessment, impact assessment, and portfolio assessment [7], [8]. Wenguang and Fan designed education information construction, information technology and teaching integration, resource construction and sharing, teacher development, student development, policies and mechanisms. It is divided into six sets of first-level indicators, 27 second-level indicators and 184 three-level indicators [9]. Although the above research constructs a more comprehensive evaluation concept model, it does not further discuss the collection method of the indicator data as evaluation evidence, nor can it further visualize these conceptual models and verify the conceptual model through implementation evaluation. Kang *et al.* [10] and Chengpeng [11] uses the analytic hierarchy process to determine the weights of each index, uses fuzzy mathematics to establish an evaluation model, and performs a two-level fuzzy comprehensive evaluation of teacher performance, making the evaluation more scientific and reasonable. However, due to the large set of indicators for performance evaluation, there will be super-fuzzy phenomenon, the resolution is very poor, and it is impossible to distinguish who has a higher degree of membership or even cause the judgment to fail. Xuemei *et al.* used the TOPSIS method for teacher performance evaluation, and used different teachers' evaluation index values to distinguish the performance of each teacher from the ideal solution and the negative ideal solution. The evaluation results are more objective and reasonable [12].

In order to achieve more objective and efficient implementation of teaching network teaching performance evaluation. This paper proposes to build a big data network teaching platform, based on the education and teaching big data, combined with principal component analysis and AHP to determine the performance evaluation system, and use the gray correlation degree to improve the TOPSIS method to establish the teacher network teaching performance evaluation model. In order to achieve the purpose of teacher network teaching performance evaluation, it provides a reference for comprehensive teacher performance evaluation in colleges and universities.

A. MAIN RESEARCH CONTENT

- Section I introduces the characteristics of the smart campus by consulting the literature, constructs the architecture model of the smart campus according to the concept of the campus Internet of Things, and builds an educational big data storage platform to provide data sources for teaching performance evaluation.
- Section II mainly analyzes the teacher performance evaluation system. Firstly, it analyzes the traditional evaluation system and constructs a scientific evaluation index system by combining the data of the network data storage platform.
- Section III presents the improvement and application of the AHP in the calculation of the weights of each evaluation index, and establishes the teaching performance evaluation model by using the TOPSIS with improved gray correlation. Finally, using the data on the network teaching platform, an example analysis of the teaching performance evaluation model is carried out.

II. SMART CAMPUS ARCHITECTURE MODEL AND DATA STORAGE PLATFORM ARCHITECTURE MODEL

A. THE CHARACTERISTICS OF SMART CAMPUS

Smart campus is the new direction of information education. Social network, cloud computing, big data, mobile technology, Internet of things and other technologies serve as the carrier and support of educational informationization, which provides new ideas for the study of educational technology. The "smart" of the smart campus lies in the application of the Internet of Things technology. Based on the Internet of Things technology, the school's things are physically connected together, the state of all things happening moments is virtually connected through the Internet, and then the useful state information is stored. Due to the huge amount of data, it is necessary to set up a corresponding data storage platform to manage the data. Finally, using the information of the detected things, the daily affairs of the university are managed. This paper mainly uses the teaching big data generated in the teaching activities to evaluate the teacher's teaching performance. Through the investigation of the literature, we learned that the smart campus has significant features in the following aspects [13].

In terms of informationization, the smart campus attaches great importance to the role of big education big data in scientific decision-making; attaches importance to multi-sectoral and multi-disciplinary services; attaches importance to the cultivation and utilization of information technology literacy of teaching assistants, and serves the construction of schools. The development of information technology in colleges and universities is mainly reflected in the comprehensive information development of colleges and universities, the integration of information technology and teaching business, and the study of new educational models [14].

In terms of technology, the application of technologies such as social networking, cloud computing, big data, Internet of Things, artificial intelligence, and virtual reality is sufficient to build virtual images for smart campuses; business cognition based on educational big data is the key technology for smart campus construction. The smart campus is to use the virtual reality technology to present the complete state of the campus. Therefore, in the construction of the smart campus model, it is necessary to provide a service framework for open technology and provide complete technical support.

In terms of construction mode, the mode of development of colleges and universities to the smart campus will be the construction mode in which the school makes overall planning and other technical institutions participate. The development model of lightweight, rapid iteration and coordinated evolution of educational information. The infrastructure of information technology is more complicated, and the campus information system and social information system, and smart campus service providers jointly guarantee the operation and maintenance mode of smart campus construction.

B. THE ARCHITECTURE MODEL OF UNIVERSITY SMART CAMPUS

The smart campus is built on the perception of real things, etc., and can transmit various types of data information in real time, and then use the information platform to organize and optimize the stored data information, and then use the information mining to realize some aspects of intelligent decision-making and control. The smart platform takes big data as the core technology, uses sensors to perceive the environment, uses network technology to connect various entities, and provides personalized services for different users based on intelligent algorithms [15]. Therefore, the building architecture model of the smart campus can be summarized as the master plan of the smart campus technology system, and the overall goal of the smart campus construction is integrated.

From the perspective of informatization, the smart campus architecture adopts a hierarchical architecture in accordance with its universalization of informationization. The hierarchical structure of the various technical elements of the smart campus application and the logical relationship between them are planned from a technical perspective.

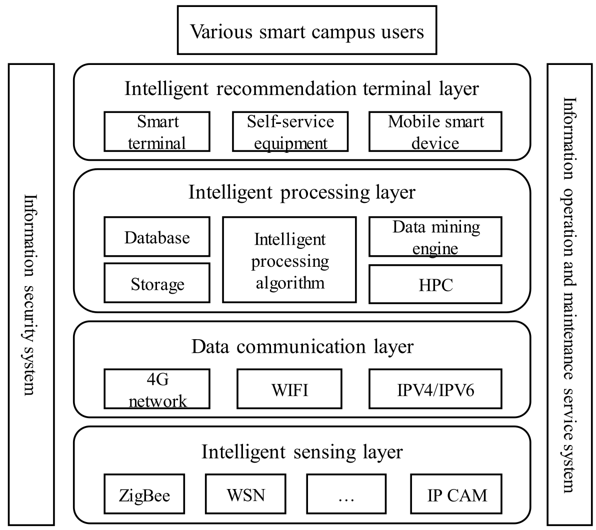

FIGURE 1. Smart campus architecture model.

From the perspective of the smart campus construction model, the information security system and the information operation and maintenance service system provide support for the smart platform [16]. The architecture consists of intelligent sensing layer, data communication layer, intelligent processing layer (Cloud Computing, Big Data), and intelligent recommendation terminal. The campus smart campus architecture model is shown in Figure 1.

- **Intelligent sensing layer:** Using ZigBee, IP CAM and other intelligent sensing users at all levels to use the data of the network, using various physical sensors to collect data on campus environment, resources, teaching and scientific research activities. Realize the comprehensive perception of user data and various environmental data at all levels of the smart campus, and provide data support for the comprehensive planning role of the smart campus.
- **Data communication layer:** Through the campus network, mobile 4G and other communication networks, the data collected by the sensing layer is transmitted and stored in time, which serves as the support for communication between the user terminals of the smart campus, and provides reliable data connection services for its data speed and speed.
- **Intelligent processing layer:** aggregates various user activities, services, interactions and other data of the sensing layer to build data support for comprehensive data for smart campuses. Integrate raw data management, intelligent algorithms, data mining engines and other technologies to achieve efficient and scientific data cloud computing services, providing scientific storage and computing support for smart campuses.
- **Intelligent recommendation layer:** based on big data technology, intelligent processing and other technologies, combined with PC, smart terminal, mobile smart device and other different terminals. Through different

network connection technologies, the company provides users with comprehensive, intelligent and personalized teaching, research, service, and management decision-making human-computer interaction modes.

- **Smart Campus Security System:** The security system is the cornerstone of the development of smart campuses. The information security security system guarantees the security of smart campus perception layer data. The information operation and maintenance service system guarantees the intelligent campus intelligent processing layer and intelligent recommendation layer, and the reliability and scientific application of data based on big data technology. The two major security systems can provide a reliable guarantee for smart campuses.

C. COLLEGE SMART CAMPUS DATA STORAGE PLATFORM ARCHITECTURE

Smart campus is based on the application of cloud computing, big data, Internet of Things, mobile internet, artificial intelligence, social network and other technologies. It is a more advanced form of information development. The application of emerging information technology enhances the development of smart campus informationization in colleges and universities. It provides the possibility to fully sense campus dynamics [17]. Teacher performance evaluation is based on a relatively complete smart campus big data application. By analyzing the application of teachers and students to the network teaching platform, the teaching tasks of the school and the network platform are organically combined, and the teaching rules of teachers are controlled by cloud computing to improve the teaching quality, improve the teaching environment and optimize the allocation of teaching resources.

According to the multi-dimensional and unstructured characteristics of the smart campus education big data, the user information of the online teaching platform is processed by ETL tools and Flume logs [18]. Relying on Hive/Pig cluster tools, distributed application coordination service tools, large-scale data computing processing tools, and distributed storage tools to complete the processing and storage of educational big data. The smart campus education data storage platform architecture is shown in Figure 2.

- **Data IntelliSense:** The method of data collection is mainly human-computer interaction. The Internet of Things technology is used to sense the campus environment and state. The intelligent devices carried by individuals in the smart campus are used for communication between people. Users are obtained through computer terminals or self-service devices. The state of use and feedback and control of its activities in learning, teaching, research, consumption, entertainment, etc., to achieve the collection of smart campus big data.
- **Smart Campus Information Collection Platform:** Realize the connection and information exchange of each campus of the smart campus through the Internet of Things technology and mobile internet technology, and map the multi-dimensional data information in the campus to the network space in time. Construct a data collection platform covering all campus coverage and campus activities.

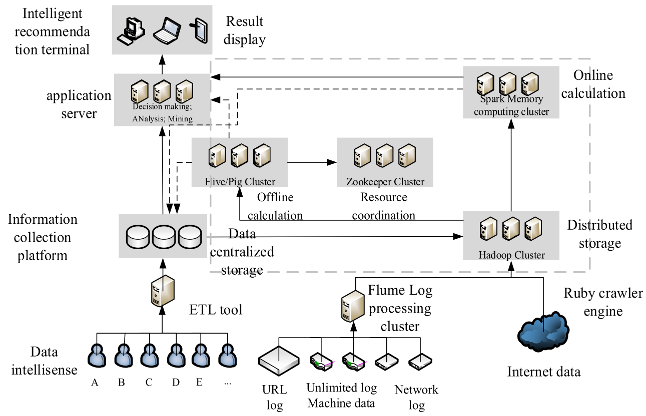

FIGURE 2. Smart campus data storage platform architecture.

- **Virtual link of smart campus:** build campus network space based on technologies such as cloud computing, cloud storage, cloud service, etc., assemble various structured, semi-structured and unstructured data generated in campus, and fully understand the data set. Then, through the smart smart devices in the smart campus, the interaction between school resources and the environment within the school is realized.
- **Intelligent recommendation terminal:** It can provide reliable basis for data reports, intelligent analysis and evaluation, personalized service, etc. required by users according to the attributes and personalized requirements of users throughout the storage process. Big data technology can be used to make decisions on school operations, resource scheduling, scientific research activities, etc. Through the integration of multi-party cooperation and social information systems, the intelligentization of personnel training mode and the innovation of scientific research activities can be realized, and then wisdom education can be realized.

III. TEACHER PERFORMANCE EVALUATION SYSTEM IN SMART CAMPUS

A. TRADITIONAL TEACHER PERFORMANCE EVALUATION SYSTEM

1) SUBJECT SELECTION OF TEACHER PERFORMANCE EVALUATION

In the traditional sense, teacher performance evaluation is based on the principles of comprehensiveness, three-dimensionality and internal and external integration. The evaluation subjects of college teachers' performance appraisal include the following [19]:

- **Examined:** Teacher self-evaluation can reflect on teaching tasks, scientific research tasks, and social service tasks from the perspective of teachers themselves, thus promoting the development and progress of college teachers' own quality and work ability. In the evaluation process, the effective combination of teacher self-evaluation and other forms of evaluation can effectively promote the improvement of teacher performance.

- **Colleague:** Colleagues' mutual evaluation can comprehensively examine the abilities, attitudes, and achievements of the evaluators in their own jobs, better promote the revision and improvement of the evaluators themselves, and promote the performance improvement of teachers in their own positions.
- **Audience:** Students are the most direct audience for teachers' work. Students' learning, student quality, and students' comprehensive development can directly reflect teachers' teaching performance. As the main audience, students' opinions on the performance appraisal of college teachers are of guiding significance for improving teacher performance and improving teaching quality.
- **Expert group:** The expert group is mainly composed of academic experts and performance appraisal experts inside and outside the school. Its role is to overcome the uncertain conclusions brought by the personal deviation of the first three evaluation subjects, and to overcome the problem of single evaluation and lack of diversity. Experts can ensure the authoritative, scientific and reliable evaluation results when evaluating teacher performance.

2) INDEX DESIGN OF EVALUATION SYSTEM

The construction of the index system of college teachers' teaching performance evaluation can not only promote the improvement of teaching quality in colleges and universities. In order to improve the school's popularity, attract high-level talents, and mobilize the enthusiasm of teaching staff, universities with different teaching attributes need to develop a scientific teacher performance evaluation system, and strengthen the incentive function of performance evaluation to stimulate the enthusiasm and creativity of the staff. In addition, due to the combination of teaching performance evaluation and performance compensation, it creates motivation for discipline construction, personnel training, scientific research and other activities. Salary pays attention to post performance and contribution, encourages teachers to explore and innovate, and promotes teachers to enter higher education levels. Based on the purpose of teaching and the improvement of teaching level, the teacher performance evaluation system is divided into five categories as shown in Table 1.

Table 1 The teacher performance evaluation system is based on the traditional form of teaching evaluation model, which is built by adding education and teaching big data. The main teaching objectives are still to improve the teaching level, the online learning indicators and online learning resource indicators have been added, and the credibility of the traditional teaching performance evaluation system has been improved.

TABLE 1. Teacher performance evaluation index system.

Primary indicator	Secondary indicators
Teaching Objectives	Realizing the unification of "knowledge transfer, ability training, quality improvement"
	Focus on cultivating students' self-learning ability and collaborative communication ability
	Completed the expected knowledge transfer goal
Teaching Content	Targeted classroom content
	The content of classroom teaching is clear
	Teaching content setting is oriented to ability development
Learning Resources	Basic information of the course should be complete
	Teaching resources are fragmented with chapter knowledge points
	Regular teaching resources updated in a timely manner
	Extensive learning resources
E-Learning	Design effective pre-course online teaching activities
	Use the network to organize students to reflect on online after-school
	Effective management of online learning activities
	Teachers and students are active in online interaction
	Focus on course data collection and analysis
Teaching Classroom Design	Building student-centered classroom instruction
	The classroom atmosphere is active, democratic, harmonious, and the relationship between teachers and students is harmonious.
	Timely adjustment of teaching rhythm and content
	Reasonable evaluation of the performance of students' classrooms
	Classroom teaching organization

B. THE COMBINATION OF SMART CAMPUS DATA STORAGE PLATFORM AND TEACHER PERFORMANCE EVALUATION

With the application of information technology in education and teaching, the smart campus data storage platform provides reliable data support for teaching performance evaluation. Using the data of college teaching activities to evaluate the performance of teachers not only avoids the waste of education and teaching data, but also provides a scientific research direction for teacher performance evaluation. The application of smart campus data storage platform data can reduce the waste of manpower and material resources, and the evaluation results are more reliable than manual evaluation.

1) ANALYSIS ON THE RESEARCH TREND OF UNIVERSITY TEACHERS' TEACHING PERFORMANCE EVALUATION UNDER THE BACKGROUND OF INFORMATIONIZATION

With the development and popularization of educational information technology, the explosive growth of online teaching data provides a new direction for teachers' teaching performance evaluation. Researchers at home and abroad on educational big data include the definition, role, opportunities and challenges of education big data, application effects, collection, development, security, and policy issues. It also studies how education big data drives the development of education; and the application of educational big data [20], [21].

Through reviewing the literature, it is found that the research of educational big data combined with teacher teaching performance evaluation mainly has the following problems: Firstly, the purpose of developmental evaluation and reward and punishment evaluation of teaching performance evaluation can not be balanced, which is one of the problems of teaching evaluation. Secondly, the selection of evaluation subjects should be multi-faceted. The single-dimensional or two-dimensional evaluation subjects have large subjective assumptions and credibility. Then, by studying the evaluation indicators in different literatures, the main problem is that the indicators are more general and there is no operability. Finally, the research literature mostly analyzes the performance model of human resource management combined with the research method of social statistics, and quantifies the qualitative evaluation index. Without real data support, the credibility of the results is not high.

In response to the above problems, by analyzing the teaching behavior of teachers using educational technology and the learning behavior education big data of students using online teaching technology, combined with the teacher teaching performance evaluation model. The education performance evaluation model driven by education big data is the focus of this study.

2) COLLECTION AND CLASSIFICATION OF EDUCATIONAL BIG DATA

Big data on the use of online courses based on statistics from the online education platform. The number of logins, the number of times to enter the course, the number of times to add personal resources, the number of times the personal resources are cited, the number of times the class is published in the class, the number of times the class is in the discussion area, the number of times the course is scheduled, and the number of times the course is corrected. It reflects the interaction between teachers and students. The number of students logging in to the platform and the number of completed assignments can reflect the enthusiasm of students. The number of teacher logins and the teacher's corrections can reflect the teacher's work attitude and the responsibility of the students.

The teaching big data in this study was collected through online interaction between students and teachers. However, online learning content is the fragmentation of knowledge points, presented in the form of chapters or units according to the time series of lectures, so that students can learn. Online learning activities include a series of online activities related to teaching, such as teacher's online guidance, student self-learning, and teacher-student interaction. Because the evaluation of teachers' teaching performance needs to be evaluated through multiple dimensions, the evaluation of teaching performance is only one-sided by relying on the educational big data of the online teaching platform. Therefore, in this study, the 26 indicators collected are classified into two primary indicators: learning resources and online learning. By evaluating these two primary indicators, a scientific teaching performance evaluation sample set is constructed as shown in Table 2.

TABLE 2. Sample set construction based on teaching big data.

Primary indicator	Secondary indicators	Three-level indicator
Learning Resources	Supply of online learning resources	The number of teaching notes; the number of test papers added; the number of video units added; the number of online test releases; the size of the resource for the broadcast unit (B); the number of online tests added; the number of test questions added; add the number of units
	Student survey	Number of course questionnaires issued; number of questionnaires participated in the course;
	Course welcome	Number of courses started; total number of courses selected; number of citations of personal resources
E-Learning	Interaction	Number of posts in the course discussion area; number of transcripts in the course discussion area; number of answers to student questions; number of blog posts; number of times blog posts were replied;
	Effective use time	Online time (minutes)
	Network teaching platform usage rate	Number of course notifications issued; number of logins; number of courses entered; number of course assignments; number of coursework

The indicators in Table 1 are qualitatively described as indicators of teaching performance evaluation. In Table 2, two levels of indicators, learning resources and online learning, are analyzed. They obtain quantitative indicator data through the interaction of students and teachers on the teaching network platform. Through preprocessing such as data elimination and screening, they can be effectively used as data samples for teaching evaluation.

The research on teaching performance evaluation is based on the educational big data provided by the smart campus Internet of Things technology. In the first chapter of the previous chapter, based on the Internet of Things technology, the smart campus education big data platform architecture was built, and the data source of the second chapter evaluation index sample set was provided. The second chapter is mainly to build the indicator set of teaching performance evaluation, and the sample data is provided by the online education platform. The next chapter is the processing of educational big data and the algorithm research on the evaluation of teaching performance.

IV. PERFORMANCE EVALUATION SYSTEM OF COLLEGE TEACHER'S NETWORK TEACHING BASED ON AHP-TOPSIS

There are many factors to consider when screening college teachers' performance indicators. A complex relationship between basic features and elements that need to be fully and accurately evaluated. Therefore, it cannot be realized by a single indicator, and multiple evaluation indexes of mutual relationship and interaction are required.

This paper focuses on the performance evaluation of colleges and universities online teaching. Firstly, the AHP is used to construct the performance evaluation index system of college teachers, and the weight of each indicator is determined. Then TOPSIS is used to evaluate the performance of online teaching of college teachers, which provides a part of reference for teachers' comprehensive performance evaluation.

A. AEVALUATION TNDEX MODEL BASED ON PCA-AHP

There are many indicators on teacher performance evaluation, and some indicators have little effect on the performance evaluation results. Therefore, when comprehensively calculating the teacher evaluation index, the principal component analysis method is used to delete the index with little influence and reduce the latitude of the calculation. Then use the analytic hierarchy process to calculate the weight of each evaluation index.

1) APPLICATION OF PRINCIPAL COMPONENT ANALYSIS

Principal Components Analysis, (PCA) replaces the original multiple variables with the synthetic variables obtained by mathematical transformation, and there is no correlation between the variables, thus achieving the purpose of mathematical dimensionality reduction [22]. Therefore, when comprehensively calculating the teacher evaluation index, the Principal Component Analysis method is used to process the data of 24 indicators and 2000 sets, and the 24 performance evaluation indicators are mathematically transformed to obtain several comprehensive variables. The use of the obtained synthetic variables instead of the original multiple variables achieves the goal of achieving mathematical dimensionality reduction. In turn, a complete evaluation index system can be obtained, and the indicator system contains all the information and the correlation between the indicators.

Step 1 (Establish a Hierarchical Analysis Model): The goals, decision criteria and decision objects of the decision are divided into the highest level, the middle layer and the lowest level according to the mutual relationship. Figure 3 is the progressive hierarchy.

Step 2 (Constructing a Judgment Matrix and Assigning It): According to the preference of experts for each evaluation index, the n indicators are compared in pairs, and then the AHP matrix is constructed, and then the weight value of each index is obtained by using the AHP matrix. The judgment

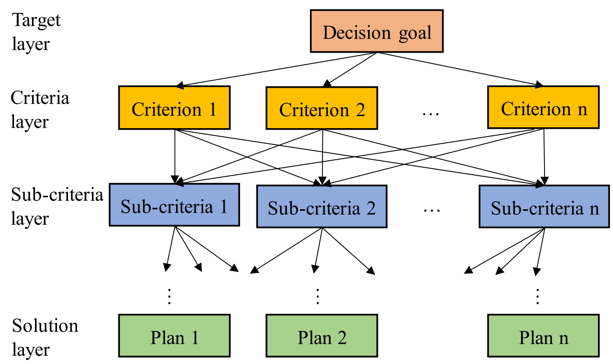

FIGURE 3. Progressive analytic structure chart.

TABLE 3. Comparison scale meaning.

Importance scale	Meaning
1	Equally important
3	Slightly important
5	Important
7	Very important
9	Extremely important
2,4,6,8	These Indicate the intermediate value of the above judgment
1/2, 1/3, 1/4, 1/5, 1/6, 1/7, 1/8, 1/9	If the ratio of the importance of element i to element j is a_{ij}, the ratio of the importance of element j to element i is. $a_{ji}=1/a_{ij}$

matrix A of AHP is:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \tag{1}$$

It represents the comparison of the i-th factor with respect to the j-th factor, and the comparison scale is 1-9 (see Table 3).

Step 3 (Calculating the Eigenvectors and Weights of the Judgment Matrix A): Normalize each column of the judgment matrix A, and its element general terms are:

$$a_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \tag{2}$$

Then, the judgment matrix B after normalization of each column is added by row:

$$a_i = \sum_{J=1}^{n} a_{ij} \tag{3}$$

Then normalize the vector $a = (a_1, a_2, \ldots, a_n)^T$ to get the weight vector of the attribute.

$$\omega_i = \frac{a_i}{\sum_{i=1}^{n} a_i} \tag{4}$$

TABLE 4. RI table.

Order	1	2	3	4	5	6	7	8
RI	0	0	0.52	0.89	1.12	1.26	1.36	1.41

Finally find the largest eigenvalue of the judgment matrix A:

$$\lambda_{\max} = \frac{\sum_{i=1}^{n} (A\omega)_i}{n\omega_i} \tag{5}$$

Step 4 (Consistency Test): The weight of the indicator can be obtained by normalizing the matrix. However, due to the subjective initiative of the people, it is difficult for the experts to ensure the consistency of the two or two judgment matrices, and it is impossible to ensure that the weights are effective and desirable. Therefore, the consistency of the judgment matrix must be tested, that is, the random consistency ratio (CR) of the judgment matrix is calculated.

(1) consistency indicator CI.

$$\mathrm{CI} = \frac{\lambda \max - n}{n-1} \tag{6}$$

(2) Lookuping table determines the corresponding average random consistency indicator RI. The average random consistency index RI corresponding to different orders of the matrix is determined as shown in Table 4.

(3) calculates the consistency ratio CR

$$CR = \frac{\mathrm{CI}}{\mathrm{RI}} \tag{7}$$

When $CR < 0.1$, it is acceptable to judge the consistency of the matrix A. When $CR < 0.1$, the judgment matrix A does not meet the consistency requirement, and the judgment matrix A is corrected.

B. PERFORMANCE EVALUATION MODEL OF COLLEGE TEACHERS BASED ON GREY CORRELATION DEGREE IMPROVEMENT TOPSIS

Order preference techniques similar to the ideal solution (TOPSIS) are an effective method commonly used in multi-objective decision analysis. This method can make up for the lack of subjective factors in comprehensive evaluation and improve the simplicity, scientificity and correctness of the teacher performance evaluation system. By defining a metric in the target space, measure the extent to which the target is close to the positive ideal solution and away from the negative ideal solution. There are no strict restrictions on data distribution and sample content indicators when applying the TOPSIS method to evaluate teachers' teaching effectiveness. This method is suitable for small sample data and large system data with multiple evaluation units and multiple indicators. It can be used for horizontal (different indicators) comparisons, as well as for vertical (multi-teacher) analysis, intuitive, reliable, and realistic [24]. Therefore, this paper uses the TOPSIS method to evaluate the teacher's teaching performance.

The study finds that the traditional TOPSIS method has a reverse order problem, and the Euclidean distance between the calculated indicators and the positive and negative ideal solutions does not take into account the correlation between the decision indicators and the different weights of the indicators. This paper draws on the improvement ideas based on the TOPSIS method in the literature and proposes an improved method.

(1) For the reverse order problem, its essence is because the positive and negative ideal solution positions change. Therefore, in order to eliminate the impact of the reverse order, it is assumed that the performance evaluation has n parameters. According to the teacher's portrait monitoring data and evaluation principles, to determine the absolute positive and negative ideal solutions for each parameter.

(2) For the correlation between performance parameters, this paper combines the gray correlation model with the TOPSIS model to standardize the positive and negative ideal distances and gray correlations. The traditional TOPSIS method is improved, and finally the purpose of correcting the relative proximity is achieved.

1) TOSTOPSIS WORKING METHODS AND PROCEDURES

The basic principle: TOPSIS method is a comprehensive evaluation method that approximates the ideal solution. Its working principle is to detect the distance between the evaluation object and the ideal solution (optimal solution) and negative ideal solution (the worst solution). Based on this, the ranking of the evaluation target columns is performed. The ordering rule is to compare each attribute index evaluation value vector of each evaluation object with the ideal solution and the virtual attribute of the negative ideal solution. If the evaluation object is closest to the ideal solution and is farthest away from the negative ideal solution, then the evaluation object is considered to be the best; the opposite is the worst.

Ideal solution: each attribute value has reached the virtual most satisfactory solution.

Negative ideal solution: Contrary to the ideal solution, each attribute value reaches the most unsatisfactory solution.

The steps to evaluate the performance of teachers using the TOPSIS method are as follows:

Step 1: Standardization of evaluation indicators

Suppose there are n teacher attributes to be evaluated to form a decision matrix $Q = (Y_{\mathrm{ij}})_{n*m}$: where y_{ij} is the j-th teaching achievement indicator value of the i-th teacher. The matrix Q can form a normative decision matrix:$Z = (z_{\mathrm{ij}})_{n*m}$, where

$$z_{ij} = \frac{y_{ij}}{\sqrt{\sum_{i=0}^{n} y_{ij}^2}} \tag{8}$$

Using the vector norm method to obtain the normative decision matrix Z, after normalization, the sum of the squares of the same attribute values of each teacher evaluation object can be obtained as 1.

Step 2: builds a weighted normative decision matrix

The column vector of matrix Z is multiplied by the total ranking weight of the index layer of the AHP method to obtain a weighted normalized decision matrix $X = (x_{ij})_{n\times m}$, as shown in equation (8).

$$X = (x_{ij})_{n\times m} = (a_j \times z_{ij})_{n\times m} = \begin{bmatrix} a_1 z_{11} & \cdots & a_n z_{1n} \\ \vdots & \ddots & \vdots \\ a_1 z_{m1} & \cdots & a_n z_{mn} \end{bmatrix} \quad (9)$$

Step 3: Determine the ideal solution and the negative ideal solution

In the teaching performance evaluation system, the indicators are all effective attribute indicators. The calculation formula of the ideal solution and negative ideal solution for the evaluation of teachers' teaching results is:

Ideal solution:

$$x_j^+ = \max x_{ij} \quad (10)$$

Negative ideal solution:

$$x_j^- = \min x_{ij} \quad (11)$$

x_j^+ and x_j^- represent the maximum and minimum values of the j indices of the normalized decision matrix X.

Step 4: Calculate the distance from the ideal solution and the distance from the negative ideal solution

The formula for each teacher to the ideal solution is:

$$s_i^+ = \sqrt{\sum\nolimits_{j=1}^{m} (x_{ij} - x_j^+)^2} \quad (i = 1, 2, \ldots, n) \quad (12)$$

The formula for each teacher to the negative ideal solution is:

$$s_i^- = \sqrt{\sum\nolimits_{j=1}^{m} (x_{ij} - x_j^-)^2} \quad (i = 1, 2, \ldots, n) \quad (13)$$

Where: s_i^+, s_i^- are the distance between the teacher and the positive ideal solution, the negative ideal solution, and x_i^+, x_i^- are the corresponding elements of the normalized decision matrix.

Step 5: Calculating the gray correlation matrix sum of each evaluation object and the positive and negative ideal solutions.

$$r_{ij}^+ = \frac{\min\limits_i \min\limits_j |x_i^* - x_{ij}| + \rho \max\limits_i \max\limits_j |x_i^* - x_{ij}|}{|x_i^* - x_{ij}| + \rho \max\limits_i \max\limits_j |x_i^* - x_{ij}|}$$

$$r_{ij}^- = \frac{\min\limits_i \min\limits_j |x_i^- - x_{ij}| + \rho \max\limits_i \max\limits_j |x_i^- - x_{ij}|}{|x_i^- - x_{ij}| + \rho \max\limits_i \max\limits_j |x_i^- - x_{ij}|} \quad (14)$$

Where ρ is a coefficient, respectively, and $\rho = 0.5$ in general.

$$r_i^+ = \frac{1}{n}\sum_{j=1}^{n} r_{ij}^+$$

$$r_i^- = \frac{1}{n}\sum_{j=1}^{n} r_{ij}^- \quad (15)$$

Step 6: Each object, the distance and correlation degree of the positive and negative ideal schemes are standardized.

$$D_i^+ = \frac{d_i^+}{\max\limits_i d_i^+}, \quad D_i^- = \frac{d_i^-}{\max\limits_i d_i^-}$$

$$R_i^+ = \frac{r_i^+}{\max\limits_i r_i^+}, \quad R_i^- = \frac{r_i^-}{\max\limits_i r_i^-} \quad (16)$$

The merged distance is associated with the gray degree, and the normalized processed distance is standardized and merged with the gray correlation degree. The combined formula is as follows:

$$C_i^+ = \frac{1}{2}D_i^+ + \frac{1}{2}R_i^+$$

$$C_i^- = \frac{1}{2}D_i^- + \frac{1}{2}R_i^- \quad (17)$$

Step 7: Calculating the relative closeness of each teacher to the ideal solution. The relative distance between the ideal evaluation solution and the negative ideal solution is calculated for each teacher's index evaluation value vector, so that the comprehensive evaluation values of each teacher are obtained and integrated.

$$C_i^+ = \frac{S_i^+}{S_i^- + S_i^+}, \quad 0 \le C_i^+ \le 1 \quad (18)$$

When the teacher's various indicators are positive ideal solutions,$C_i^+ = 1$, when the teacher's various indicators are negative ideal solutions, $C_i^+ = 0$, in general, the teacher's closeness C_i^+ is (0, 1), reflects the extent to which teachers are close to positive ideal solutions.

Step 8: program ranking

Sorting C_i^+ from large to small, the larger C_i^+, indicating that the teacher's teaching results are more significant, which is worthy of recognition.

V. TEACHER NETWORK TEACHING PERFORMANCE EVALUATION APPLICATION EXAMPLE

A. DATACOLLECTION

Due to the prevalence of online learning, colleges and universities have gradually attached importance to online teaching activities. This paper mainly evaluates the performance of online teaching in colleges and universities. Through the foundation of the big data platform established above, some teacher information and network teaching information in the sample are collected. Questionnaire survey was conducted on 20 experts related to human resources, and 24 indicators of teacher performance evaluation were finally determined: the number of teaching notes Z_1, the number of test papers added Z_2, the number of videos added to the class unit Z_3, and the number of online tests Z_4 Add the number of test papers Z_5, add personal resources Z_6, add the number of broadcast units Z_7, publish the number of questionnaires Z_8, participate in the number of questionnaires Z_9, the number of courses Z_{10}, the total number of courses Z_{11}, the number of individuals voluntarily cited Z_{12}, courses Number of posts in

TABLE 5. Partial raw data.

Teacher serial number	Learning Resource s	Online Learning	Online Learning	Learning Resource s	Online Learning
T1	5.47	3.15	T6	5.67	6.10
T2	8.12	3.11	T7	6.78	8.41
T3	4.21	6.12	T8	3.12	4.67
T4	4.89	6.12	T9	5.41	5.52
T5	7.12	7.32	T10	6.79	7.12

TABLE 6. Index component matrix (partial data).

r1		r2		r3	
z1	0.534	z17	0.438	z23	0.664
z6	0.462	z15	0.361	z24	0.572
z4	0.341	Z18	0.260	Z25	0.268
…	…	…	…	…	…
r4		r5		r6	
z11	0.703	z8	0.427	z19	0.371
z12	0.538	z9	0.358	z17	0.08
z10	0.461	z4	-0.036	Z24	0.04
…		…		…	

the discussion area Z_{13}, number of transcripts in the discussion area Z_{14}, number of answers to student questions Z_{15}, number of times to post blog articles Z_{16}, number of times the blog post was replied Z_{17}, number of posts to be published Z_{18}, online duration Z_{19}, number of course notifications Z_{20}, login The number of times Z_{21}, the number of times to enter the course Z_{22}, the number of scheduled coursework Z_{23}, and the number of coursework assignments Z_{24}.

Part of the raw data is processed by the above big data platform. As shown in Table 5.

B. USING PCA TEST AND SCREENING INDICATORS

There are a total of 24 performance evaluation indicators, and there are a large number of indicators. There may be some correlation between the indicators. Therefore, firstly, using SPSS, 24 indicators and a total of 2000 sets of data are dimensioned to obtain matrix. Then, the correlation coefficient matrix R is obtained for the matrix the eigenvalue of the coefficient matrix R is, the corresponding eigenvector is, and the coefficients of the eigenvector are arranged in descending order, as shown in Table 6.

According to the coefficient size of the feature vector α in Table 6, the index ranked first is selected. If the coefficient corresponding to the index is less than 0.1, it indicates that the index has little influence on the principal component, and the index is excluded.

First, a set of principal components Y_s can be obtained.

$$Y_s = \sum_{i=1}^{m} \alpha_i X_i, \quad (i = 1, 2, \ldots, m) \tag{19}$$

When the cumulative contribution rate of the current k principal components is greater than or equal to 80%, and the eigenvalue $\lambda > 1$, the first k indicators are selected as the main component, and the remaining indicators are ignored. The crushed stone map obtained by SPSS is shown in Figure 4.

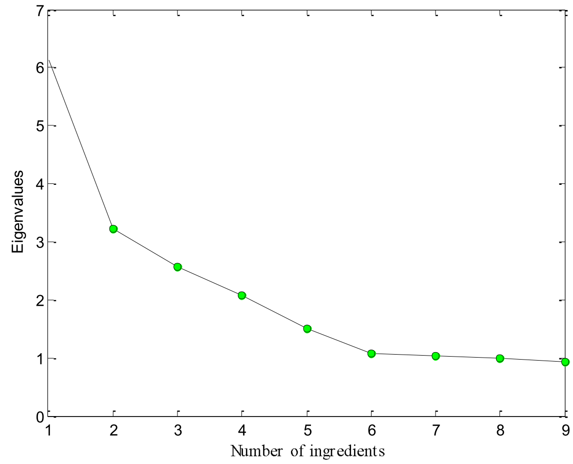

FIGURE 4. Scree test.

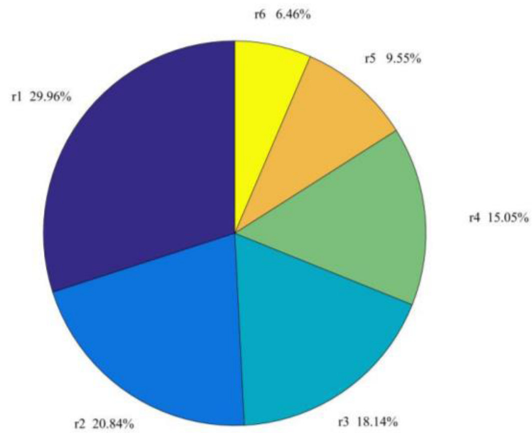

FIGURE 5. Six principal component weight distributions.

It can be seen from the gravel diagram that the eigenvalues of the first six principal components gradually decrease, and the eigenvalues do not change much after the seventh principal component. The cumulative contribution rate of the first six principal components is calculated to be 83.72%, so the first six principal components can express all the indicator information. Combine the results of the indicators in Table 6 to obtain the evaluation index system. According to the meaning of the indicators, the six principal components are named as: network learning resource supply (r1), student questionnaire (r2), course welcome (r3), interaction (r4), and effective use duration (r5) the network teaching platform usage rate (r6), their weight distribution is shown in Figure 5. Then construct two criteria: learning resources and online learning; the target layer of the performance evaluation index system is shown in Figure 6.

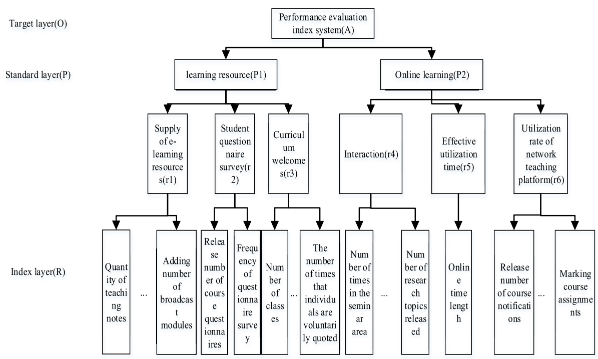

FIGURE 6. Evaluation index system.

TABLE 7. A-P judgement matrix.

A-P	P1	P2
P1	1	2
P2	1/2	1

C. USE AHP TO DETERMINE INDEX WEIGHT

Some of the criteria for evaluating the attributes of teachers' evaluation indicators are qualitative and some are quantitative. The influence of different criteria on evaluation is also different. Whether the weight distribution is scientific and reasonable will directly determine the accuracy of the evaluation results [25]. Therefore, AHP is used to calculate the weights of each index in the progressive hierarchy model of evaluation index [26].

Through a questionnaire survey of 20 human resource experts, the importance of each index was evaluated. The judgment matrices of each factor in criterion layer P1 and sub-criterion layer P2 and indicator layer R were calculated. The judgment matrices of A-P, P1-R and P2-R were shown in Table 7–9 respectively.

Through a questionnaire survey of 20 human resource experts, the importance of each index was evaluated. The judgment matrices of each factor in criterion layer P1 and sub-criterion layer P2 and indicator layer R were calculated. The judgment matrices of A-P, P1-R and P2-R were shown in Table 7-9 respectively.

According to the judgment matrix shown in Table 5-8, the maximum eigenvalue of A-P matrix $\lambda_{\max} = 3.054$, $CI = 0.027$, $RI = 1.12$ and $CR = 0.006 < 0.1$, are calculated, which satisfies the consistency test. Therefore, the weight matrix W=[0.225, 0.252] is acceptable.

Similarly, the P1-R matrix: $\lambda_{\max} = 5.012$, $CI = 0.008$, $RI = 1.12$, $CR = 0.012 < 0.1$ satisfies the consistency test. The weight matrix W=[0.311,0.196,0.493] is acceptable.

P2-R matrix: $\lambda_{\max} = 4.054$, $CI = 0.017$, $RI = 1.15$, $CR = 0.002 < 0.1$ satisfies the consistency test. The weight matrix 错误!未找到引用源。W=[0.641,0.225,0.375] is acceptable.

TABLE 8. P1-R judgement matrix.

P1-R	r1	r2	r3
r1	1	2	1/2
r2	1/2	1	1/2
r3	2	2	1

TABLE 9. P2-R judgement matrix.

P1-R	r1	r2	r3
r1	1	2	3
r2	1/2	1	2
r3	1/3	1/2	1

TABLE 10. Normalized decision matrix.

Number	learning resource	Online learning	Number	learning resource	Online learning
T1	0.292	0.166	T6	0.302	0.322
T2	0.433	0.164	T7	0.362	0.444
T3	0.225	0.323	T8	0.166	0.246
T4	0.261	0.323	T9	0.289	0.291
T5	0.380	0.386	T10	0.362	0.376

According to the evaluation model constructed by 3.2, we can achieve the performance evaluation of university teachers in four steps.

(1) The normalized decision matrix is calculated according to formula (8) (table 10).

(2) Based on the index weight a calculated by $a = (0.225, 0.252)$ 错误!未找到引用源。According to equation (6), the weighted gauge matrix is obtained (Table 11).

(3) determine the ideal solution vector x_j^* 错误!未找到引用源。and "negative ideal solution vector".

$$\begin{cases} x_j^* = (0.975, 0.993) \\ x_j^- = (0.374, 0.422) \end{cases}$$

(4) The comprehensive evaluation values of each evaluation object were calculated and sorted synthetically.

According to formula (12), the relative distance between the index evaluation value vector of the teacher sample and the ideal solution and the negative ideal solution is calculated, and the comprehensive ranking result is obtained. As shown in Table 12.

According to the evaluation results, the scores of 10 teachers ranged from 0.212 to 0.840, and the order of repair techniques was T7, T5, T10, T6, T4, T9, T2, T3, T1, T8. Among them, the teaching results brought by more ideal teachers are learning resources and online learning stabilization. In the performance evaluation of the campus classroom, the school

TABLE 11. Weighted normal matrix.

Number	learning resource	Online learning	Number	learning resource	Online learning
T1	0.657	0.427	T6	0.681	0.827
T2	0.975	0.422	T7	0.814	1.141
T3	0.505	0.830	T8	0.374	0.633
T4	0.587	0.830	T9	0.649	0.749
T5	0.855	0.993	T10	0.815	0.966

TABLE 12. Comprehensive ranking results.

Teacher		TOPSIS value
Number	Ranking	
T1	9	0.265327
T2	7	0.454981
T3	8	0.432397
T4	5	0.480915
T5	2	0.79665
T6	4	0.541792
T7	1	0.839698
T8	10	0.212147
T9	6	0.456066
T10	3	0.747159

unit chose T7 as the best teacher, which is in good agreement with the results of the index system.

VI. CONCLUSION

- This paper analyzes the distinct characteristics of smart campus from various angles, and constructs a smart campus architecture model. Aiming at the research content of teaching performance evaluation, this paper establishes a framework model of educational data collection and storage platform for smart campus, which provides a reference model for the construction of smart campus in universities.
- A comprehensive evaluation index system of teachers' performance evaluation is constructed based on the basic principle of AHP. The evaluation index of the factors affecting teachers' performance is determined from two aspects of learning resources and online learning, which ensures that the weight of the factors of teachers' performance evaluation is properly distributed and avoids the limitation of artificial judgment in performance evaluation. The calculation of TOPSIS closeness is improved by grey relational degree, and the quantitative basis of the teachers to be tested and the ideal samples is improved. Using the improved TOPSIS method to get the evaluation matrix constructed by the closeness degree of each evaluation index, and through the demonstration of the application of examples, the teacher performance evaluation results of the AHP-TOPSIS evaluation model are consistent with the actual situation.
- The combination of PCA and AHP-TOPSIS in the analysis of teacher performance evaluation results, AHP method can effectively overcome the drawbacks of TOPSIS method because of too many factors and difficult to allocate weight, but also avoid subjective factors caused by decision-making mistakes, can make a more scientific, comprehensive and accurate judgment.

The research shows that the combination of the intelligent campus data platform and the three algorithms can effectively evaluate the teaching performance of teachers, and make the evaluation results of teachers' professional titles more pertinent, which can be used as a theoretical basis for decision-making, and provide a new method for evaluating the system results. It avoids the traditional irrationality of summing up all index scores.

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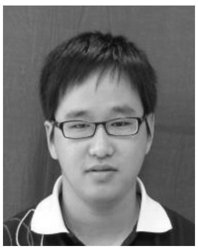

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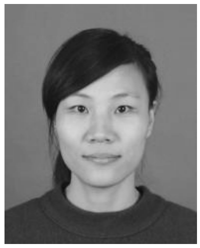

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