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Analysis of the Effectiveness of Industry-Teaching Integration and Collaborative Education and Training in the Evaluation of CIPP Model of Modern Industrial Colleges Based on Principal Component Analysis

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ABSTRACT

In recent years, China's research investment in colleges and universities has gradually increased, but not much research and exploration has been done on the construction of the evaluation index system for the integration of industry and education. The state, society, industry and so on have brought rare opportunities for the implementation of in-depth integration of industry and education, which also indicates the imperative of the development of integration of industry and education. Based on the practical significance of educational evaluation, this paper applies the CIPP model to the construction of the quality evaluation system for collaborative education and training in university modern industrial colleges in view of the high degree of fit between the CIPP model and the process of university-industry-industry fusion activities in university modern industrial colleges. The recursive hierarchical structure is established according to the established index system, and the weights of the index system are calculated through the consistency test. The factor loading matrix of the first three principal components is constructed, and the modern industrial colleges are evaluated according to the principal components, and the mean values of the principal components 1, 2, and 3 are 0.27, 0.096, and -0.0186, respectively.In the calculated quality evaluation results of the integration of industry and education in modern industrial colleges, the score of educational and teaching achievements of the modern industrial colleges in Zhejiang Province is relatively low at 85.8439, which indicates that there is a gap in educational and teaching achievements, and there is a need to further improve the education and teaching achievements of modern industrial colleges. In addition, there are differences in the evaluation of the quality of industry-education integration in different modern industrial colleges in

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Zhejiang Province.The results of this study indicate that it is necessary to further optimize the construction path to meet the actual needs of industry-teaching integration in Zhejiang Province.

Keywords: CIPP model, recursive hierarchy, factor loading matrix, industry-education integration

1. Introduction

Deepening the integration of higher education industry and education, and the joint education of schools and enterprises are the most important tasks in improving the level of education supply. China's "government-enterprise-school" collaborative education has been going on for some time, but problems such as inconsistent expectations, conflicting interests and uneven distribution of resources have made it impossible for "government-enterprise-school" cooperation to be carried out in depth [1-2]. Through the optimization of "government-enterprise-school" collaborative education incentive path, deepen the integration of production and education mode of schooling, improve the talent training program of universities, is conducive to promoting the overall quality of higher education, is conducive to college students to establish a sense of employment, enhance the overall competitiveness, fully mobilize the "government-enterprise-school" tripartite enthusiasm, and fully mobilize the "government-enterprise-school" tripartite enthusiasm. Fully mobilize the enthusiasm of "government, enterprise and school", so that "government, enterprise and school" collaborative education subject complement each other's strengths, share resources, explore new technologies, research and development of new products [3-6]. Industry-education integration community refers to the new organizational form of industry-education integration under the guidance of government policy, led by leading enterprises and high-level higher education institutions and vocational schools, with the participation of industry organizations, schools, research institutions, upstream and downstream enterprises, to bring together the resources of industry and education, and the in-depth fusion of education and industry to achieve common development [7-9]. It is a new carrier for the integration of industry and education, which can promote the effective docking of talent training and industrial demand, help industrial transformation and upgrading, and provide strong support for economic and social development [10]. The community of industry-education integration is different from the traditional organizational form, it is a new organizational form of talent training and social and economic development closely integrated in the new era, formed on the basis of resource sharing, complementary advantages, common goals and value pursuits, and synergistically developed through the government, industry, enterprises and schools to work together and give full play to their respective advantages [11-12].

In this organization, the government occupies a dominant position in the community of industry-education integration. The government takes the lead in building a cooperation platform, formulating policies, improving local laws and regulations, standardizing the respective rights and obligations of the pluralistic subjects, and implementing support policies such as taxation and funding, so as to provide policy and institutional safeguards for the development of the community of integration of industry and education [13-14]. The government plays the function of macro-control, planning and guiding the development, macro-controlling the collaborative relationship between industry and education, and promoting the deep integration of education and industry [15]. Schools shoulder the mission of cultivating talents for the country. Through cooperation with enterprises, schools buttress the needs of industry, adjust professional settings and professional standards, promote talent cultivation to meet the needs of industrial development, and realize the precise convergence with industrial talent needs. The cooperation among the subjects of the community of industry-education integration is all-round [16-17]. While cooperating in the field of education and teaching, schools and enterprises cooperate in many aspects such as scientific research, technology development and improvement, and transformation of technological achievements. Enterprises are an important part of the community of industry-education integration, playing the role of the main body of education. Enterprises participate in the whole process of talent cultivation through cooperation with schools, not only to meet the enterprise's own talent needs, the integration of corporate culture and philosophy, but also to reserve talents for their own sustainable development [18-19]. Through the cooperation with the school, with the help of the school's scientific research power, help enterprise technology research and development and improvement, improve the core competitiveness of enterprises and promote industrial development. Research institutes are also an important part of the community of industry-education integration. By virtue of their strong scientific research strength and innovation ability, scientific research institutes lead the technological frontier, promote the breakthrough of key common technologies, help enterprises solve technical problems, promote technological innovation, and provide technical support for industrial upgrading and transformation [20-21]. Research institutes and schools, enterprise technology research and development personnel cooperation, to provide cutting-edge technical support for enterprises, R & D talent support, joint research and development of new technologies, to promote the transformation and application of scientific and technological achievements, to achieve a close integration of science and technology and the economy [22]. In recent years, the integration of industry and education has achieved results in practice, but there are still problems such as "integration but not harmony" and "cooperation but not deep", so it is necessary to explore solutions from the perspective of collaborative education mechanism [23].

In this paper, starting from the four links of the CIPP model, we studied the process of industry-education integration activities in modern industrial colleges of universities. Using the principal component method to propose comprehensive indicators, and it will be initialized indicator processing, expressed through mathematical equations, to establish the initial indicator value matrix. Sequentially do the same trend of data, dimensionless, ex ante test and a series of empowerment of basic procedures to deal with, design the university modern industrial college of industry and education fusion quality evaluation system, and gradually calculated the weights of the index system in the index system of the modern industrial development college of each university in Zhejiang Province into the innovation and deepening of the pilot of the first level and second level indicators. The principal component analysis is carried out on the data of the indicators of the integration of industry and education in the modern industrial colleges of the universities to get the quality score of the integration of industry and education, and the optimization path of the integration of industry and education is further proposed according to the evaluation results.

2. Collaborative education for industry-teaching integration in modern industrial colleges based on the CIPP model

2.1. *CIPP model*

CIPP model is widely used in the field of education evaluation. The model focuses on the comprehensive evaluation of education quality and on the joint role of factors within the system on education quality, so it is more adequate and reasonable [24] The four segments of the model are sufficiently appropriate to the process and concept of industry-teaching integration activities of modern industrial colleges in universities and can be applied to the construction of the quality evaluation index system of industry-teaching integration and collaborative education in modern industrial colleges in universities.

In the background evaluation, the evaluators need to evaluate the needs, problems, favorable conditions and opportunities, as well as the related background conditions and dynamics. In input evaluation, evaluators assist in the development of the project plan by identifying and evaluating alternative methods, followed by the evaluation of the process plan, staffing and budget, clarifying the feasibility and potential cost-effectiveness related to meeting the established needs and attaining the desired goals. In process evaluations, evaluators monitor, document, evaluate and report on the implementation of project plans. In outcome evaluations, evaluators identify and evaluate costs and results, including intended and unintended outcomes, short-term and long-term results.

Figure 1 shows the core components of the CIPP model, with 3 concentric circles depicting the basic elements of the CIPP model, where the inner circle represents the core value, which is used to emphasize a given evaluation. The circle that surrounds the outer core value is divided into 4 evaluation foci, i.e., goals, plans, actions, and outcomes. The outermost circle is oriented to the types of evaluations for the 4 evaluation foci, i.e., background evaluation, input evaluation, process evaluation, and outcome evaluation. Goal-setting tasks pose questions for background evaluations that inform the identification and improvement of goals. Program improvement tasks pose questions for input evaluations, which accordingly provide program critiques and directions for program enhancement. Project actions also raise questions for process evaluation, and these questions provide critiques of the actions and reinforce feedback on the work. Accomplishments, lack of accomplishments, and side effects control attention to outcome evaluations, which ultimately produce outcome judgments and help identify needs for better outcomes.

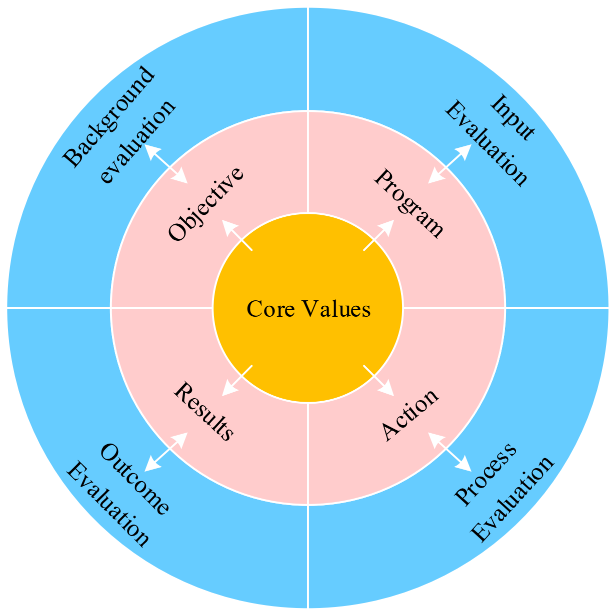

Fig. 1. Core components of CIPP model

2.2. Principal Component Analysis Study

2.2.1. Basic Principles and Mathematical Models of Principal Component Analysis. The mathematical idea can be expressed in this way, still have n initial indicator is z_j, using the principal component method extracted p composite indicator $x_i\left(i=1,2,\cdots p, p\leq n\right)$, to use a few p composite indicators to truly reflect the internal structure of the n initial indicator [25]. Let the initial indicator after the standard treatment be expressed as $z_j^*\left(j=1,2,\cdots n\right)$. The mathematical equation can be expressed as follows:

$$\begin{cases} x_1 = a_{11}z_1^* + a_{12}z_2^* + \cdots + a_{1n}z_n^* \\ x_2 = a_{21}z_1^* + a_{22}z_2^* + \cdots + a_{2n}z_n^* \\ \cdots\cdots \\ x_p = a_{p1}z_1^* + a_{p2}z_2^* + \cdots + a_{pn}z_n^* \end{cases} \tag{1}$$

In the above system of equations, $x_1, x_2, \cdots\cdots x_p$ is the p principal components extracted from the initial data using principal component analysis, where x_1 is called the first principal component, x_2 is called the second principal component, and so on for the others. The greater the variance $VAR(x_p)$ of each principal component, the greater the amount of information it covers, i.e., the variance $VAR(x_1)$ of the first principal component is the first among all principal components. Usually when the information covered by the first principal component is not enough to reveal the internal structure of the initial data, it is considered that there should be a second principal component, and so on for the rest, until the information covered by the p principal components is enough to represent the information of the initial data.

After introducing the basic operating principles of principal component analysis, the next article will further investigate the mathematical model of this method. It is still assumed that there are m objectives to be evaluated and n indicators, and the matrix consisting of the initial indicator values is expressed as:

$$Z = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1n} \\ z_{21} & z_{22} & \cdots & z_{2n} \\ \vdots & \vdots & & \vdots \\ z_{m1} & z_{m2} & \cdots & z_{mn} \end{bmatrix} = (Z_1, Z_2, \cdots Z_n) \tag{2}$$

Here Z_j denotes the j nd column matrix where $j = 1, 2, \cdots n$.

Before the implementation of principal component analysis, the initial data need to be processed by the dimensionless method to eliminate the interference factors induced by different scales. When using SPSS software for principal component analysis, the system usually uses standardization method directly to dimensionless the initial data.

Let $X = (x_1, x_2, \cdots x_n)$ be the matrix after the implementation of the dimensionless treatment of the initial indicator values, then the composite indicator vector F can be linearly represented by the standardized n initial indicators in the process of the principal component approach:

$$\begin{cases} F_1 = b_{11}x_1 + b_{12}x_2 + \cdots + b_{1n}x_n \\ F_2 = b_{21}x_1 + b_{22}x_2 + \cdots + b_{2n}x_n \\ \cdots\cdots \\ F_n = b_{n1}x_1 + b_{n2}x_2 + \cdots + b_{nn}x_n \end{cases} \tag{3}$$

It is worth noting that the combination of equations in the above equation requires ${b_{j1}}^2 + b_{j2}^2 + \cdots + b_{jn}^2 = 1(j = 1, 2, \cdots n)$.

And the following principles also determine the principal component coefficients b_{tj}, which are expressed as follows:

1) For n composite indicators $F_1, F_2, \cdots F_n$, $Cov(F_u, F_v) = 0$, where $u \neq v, u, v = 1, 2, \cdots n$ in other words, n composite indicators two by two are independent of each other.

2) For all principal components, only the first principal component F_1 is the one with the highest variance among all linear permutations of $x_1, x_2, \cdots x_n$, i.e., $\mathrm{VAR}(F_1) \succ \mathrm{VAR}(F_t)(i \neq 1, i = 2, 3, \cdots n)$; F_2 is the one with the highest variance among $x_1, x_2, \cdots x_n$ linear permutations that are uncorrelated with F_1. By analogy, similarly F_n is the first in variance among the $x_1, x_2, \cdots x_n$ linear permutations that are all uncorrelated with $F_1, F_2, \cdots F_{n-1}$.

2.2.2. Steps in principal component analysis:

1) Trendization. Let there be m object to be evaluated and n indicators to be evaluated, then the matrix formed by the initial data can be expressed as $Z = (z_{ij})_{m\times n}$.

2) Quantity-free Tempering. Here it is still assumed that there are m targets to be evaluated, n indicators, the matrix composed of the initial indicator values is expressed as $Z = \left(z_{ij}\right)_{m\times n} \left(i = 1, 2, \cdots m; j = 1, 2, \cdots n\right)$, and here the maximum value of the j th indicator is expressed as $\max\left(z_j\right)$, the minimum value of the j th indicator is expressed as $\min\left(z_j\right)$, and the matrix composed of the initial data is z_{ij}, and the standardized matrix after the dimensionless treatment is expressed as x_{ij}. When using SPSS software to do principal component analysis, the system will automatically use the standardization method to implement the initial indicator values of dimensionless disposal. The formula used in it can be expressed as:

$$x_{ij} = \frac{z_{ij} - \overline{z}_j}{s_j} \tag{4}$$

$$\overline{z}_j = \frac{\sum_{i=1}^{m} z_{ij}}{m} \tag{5}$$

$$s_j = \sqrt{\frac{\sum_{i=1}^{m}\left(z_{ij} - \overline{z}_i\right)^2}{m-1}} \tag{6}$$

In the above equation, $i = 1, 2, \cdots m$, $j = 1, 2, \cdots n$, x_{ij} denote the matrix composed of initial data z_{ij} after dimensionless processing, $\overline{z}$, is the mean of the j th indicator of the initial data, s_j is the standard deviation of the j th indicator of the initial indicators.

3) Ex ante test. Take the principal component method to implement empirical analysis is a prior condition, that is, the data indicators should have a relatively high correlation between the data indicators, not all the data indicators can be qualified to use out of the component method to implement the analysis, so here we need to do a pre-test [26].

4) Calculation of eigenvalues and eigenvectors. After the prior test has been passed, the principal component method can then be used to implement further analysis. Since the initial data of the article has been implemented dimensionless disposal, the calculation of principal components is based on the basis of the covariance matrix. Since the article assumes that there are m target to be evaluated and n indicators initial indicators, the random variable after the dimensionless disposal is denoted by $X = \left(X_1, X_2, \cdots X_m\right)$, so that $X^T = \left(X_1, X_2, \cdots X_m\right)^T$, can be derived:

$$X^T = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \tag{7}$$

Then the covariance matrix of the initial matrix $X = \left(X_1, X_2, \cdots X_m\right)$ after dimensionless quantization can be expressed as $C = \frac{1}{m} XX^T$, and the n eigenvalues $\lambda_j \left(j = 1, 2, \cdots n\right)$ of the covariance matrix can be derived from the eigenequation $|C - \lambda I| = 0$. It can be shown in the algebraic domain that the eigenvalues λ_j are also the variances of the principal components. Denote the eigenvector corresponding to each eigenvalue λ_j as U_f, and $U_j=\left(u_{1j},u_{2j},\cdots u_{nj}\right)\left(j=1,2,\cdots n\right)$. Depending on the magnitude of the resulting eigenvalues, it is generally accepted that principal components with eigenvalues exceeding 1 should be taken out on a merit basis.

Denote the principal component expression as $F_j=U_j\times X_j$, i.e. $f_i=u_{1j}\times x_n+u_{2j}\times x_{i2}+\cdots+u_{mj}\times x_m\left(t=1,2,\cdots m;j=1,2,\cdots n\right)$.

5) Contribution rate calculation. After obtaining the characteristic root, the contribution rate of variance in the middle can be calculated V_j, and the formula is as follows:

$$V_j=\frac{\lambda_j}{\sum_{j=1}^{n}\lambda_j} \tag{8}$$

It is also possible to construct the variance cumulative contribution rate, and the variance cumulative contribution rate V_i' is the sum of the variance contribution rates of the first k eigenroots, calculated as follows:

$$V_i'=\sum_{i=1}^{k}\left\{\frac{\lambda_j}{\sum_{j=1}^{n}\lambda_j}\right\} \tag{9}$$

The variance contribution rate is also the amount of information covered by the composite variable, the larger the variance contribution rate indicates that the composite variable plays a greater role in the initial data.

6) Rotate the loading matrix. After deriving the component matrix in the above steps, the component matrix is rotated using the maximum variance method, and the rotated component matrix can be obtained.

7) Derive the weighting coefficients. After extracting k principal component, the relative contribution of variance C_{t} of a particular principal component can be derived using the formula as follows:

$$C_t=\frac{\lambda_t}{\sum_{t=1}^{k}\lambda_t} \tag{10}$$

where the number of principal components extracted is denoted by k and the eigenroot is denoted by λ, then the relative contribution of variance of the t rd principal component is denoted by C_t. In addition the contribution of the t th eigenvector to the j th indicator can be deduced by the formula U_y and the mathematical expression can be written as:

$$U_{tj}=\frac{A_{ij}}{\sqrt{\lambda_i}} \tag{11}$$

where $t=1,2,\cdots k$, the number of extracted principal components is represented by k, λ is the characteristic root, and A_t represents the loading value of a principal component in the component matrix projected on the j th indicator, so that it is possible to derive the coefficients of the representative weights of each indicator to express the formula:

$$\beta_j = \sum_{t=1}^{k} \left(\left| U_{tj} \right| \times C_t \right) \tag{12}$$

8) Calculation of indicator weights. After calculating the proportion of the weights represented by all the indicators, the proportion of each weight can be processed using the normalization method to obtain the weights represented by all the indicators, and the processing formula is as follows:

$$W_j = \frac{\beta_j}{\sum_{j=1}^{n} \beta_j} \tag{13}$$

It is obvious that the weight of each indicator is W_f, and the number of all indicators is n.

The above eight steps is the use of principal component method to give weight to the basic procedures experienced in the actual operation does not need to calculate these eight steps, the article is just to make the process of principal component weighting method is more clear, to split each step to explain in detail. The article is in accordance with the requirements of the above steps, step by step calculation of the weights of the primary and secondary indicators in the index system of modern industrial development colleges and universities in Zhejiang Province, which are included in the innovation and deepening of the pilot.

3. Construction of the indicator system

3.1. Indicator system design

In designing the indicator system, the first should follow the principle of balancing the interests of the relevant core subjects, the second should follow the principle of evaluating systematically and scientifically, and the third should implement the principle of combining qualitative and quantitative.

3.1.1. Tier 1 indicator construction. In December 2017, the General Office of the State Council issued Several Opinions of the General Office of the State Council on Deepening the Integration of Industry and Education, and in May 2021, the Ministry of Education and three other ministries and commissions jointly issued the Implementation Plan for the Project of Promoting a Stronger Education in the Fourteenth Five-Year Plan Period. Based on the CIPP model and analyzing the above documents, the three first-level evaluation indicators of “talent cultivation quality”, “education and teaching achievements” and “innovation and entrepreneurship achievements” were obtained. Corresponding to the three dimensions of the model.

3.1.2. Construction of secondary indicators:

1) Selection of “Talent Cultivation Quality” Dimension Indicators. (1) the professional sites under construction have passed the national professional certification or professional assessment, (2) the teaching quality assurance system is well constructed, and the operation mechanism and effect are good, (3) the employment rate, the degree of relevance of professional counterparts, and the salary level are in the forefront of the same kind of colleges and universities, and (4) the characteristics of talent cultivation are distinctive, and the employers' satisfaction with the graduates is high.

2) Selection of indicators for the dimension of “educational and teaching achievements”. (1) modern industrial colleges supported by the Ministry of Education and the Ministry of Industry and Information Technology, (2) collaborative education projects of the Ministry of Education or research

and practice projects of new engineering, new medical science, new agricultural science and new liberal arts, (3) provincial education reform projects and teaching achievement awards at or above the provincial level, (4) first-rate majors, first-rate courses and excellent teaching villages at or above the provincial level, and (5) provincial “five batch” projects of integration of industry and education. “Five batch” projects.

3) Selection of Indicators for “Innovation and Entrepreneurship Achievement” Dimension. (1) Outstanding innovation and entrepreneurship education achievements, (2) High percentage of innovation and entrepreneurship among students and graduates, (3) Gold medals in various influential competitions such as national and provincial “Internet+” Innovation and Entrepreneurship Competition for College Students and “Challenge Cup” series competitions.

3.1.3. Tertiary indicator construction. On the basis of the established first and second level evaluation indexes, and following the principle of authority and accessibility of evaluation index data, referring to the key construction task indexes of the integration of industry and education involved in national and provincial policy documents, utilizing the model selected in this paper, and combining the statistical and research methods, the three-level index system of evaluation of the quality of the integration of industry and education in the modern industrial colleges of the universities was finally constructed.

3.2. Indicator weights

According to the established index system to establish a recursive hierarchical structure, on the basis of hierarchical analysis, combined with expert scoring, and then through the consistency test, through the expert group to give the results of the corresponding indicators to obtain the final weights, Table 1 shows the evaluation indicators and weights of the evaluation indicators of industry-teaching integration and collaborative training cultivation in the modern industrial development colleges in Zhejiang Province. The weights of the three evaluation indicators of talent cultivation quality, education and teaching achievements as well as innovation and entrepreneurship achievements are 0.3315, 0.3454 and 0.3231 respectively.This expert group consists of nine experts from the government(The Education Department of Zhejiang Province,Zhejiang Provincial Department of Economy and Information Technology), modern industrial colleges of colleges and universities, enterprises, and other departments related to the activities of industry-teaching integration.

Table 1. The evaluation index of the combination of production and education

Primary index	Weighting	Secondary index	Weight
Talent cultivation quality	0.3315	Specialist assessment(C1)	0.0825
		Quality of teaching(C2)	0.0826
		Employment, professional correlation(C3)	0.0846
		The employer has high satisfaction with graduates(C4)	0.0818
Education results	0.3454	The modern industry college, which supports construction(C5)	0.0692
		Collaborative education(C6)	0.0675
		The results of the above teaching(C7)	0.0698
		The excellent teaching village above the provincial level(C8)	0.0684
		"Five groups" project(C9)	0.0705
Innovation and entrepreneurship	0.3231	Innovation and entrepreneurship education(C10)	0.1164
		The proportion of college and graduate innovation(C11)	0.1046
		In countries, provincial "challenge cup" series competition, etc., won the gold medal(C12)	0.1021

4. The quality of CIPP's industry-teaching integration and collaborative education based on principal component analysis

4.1. Data Analysis of Industry-Education Integration Indicators for Modern Industrial Colleges in Higher Education Institutes

4.1.1. Reliability and validity analysis. The scope of this survey involves the front-line teaching staff, teaching managers, and students of five provincial key modern industrial colleges including the Modern Industrial College of Digital Manufacturing of Zhejiang University of Technology, the Modern Industrial College of Textile and New Materials of Zhejiang Sci-Tech University,the Industrial College of Ophthalmology and Optometry of Wenzhou Medical University,the College of Cross-border E-commerce of Zhejiang Gongshang University,the College of Hangzhou Bay Automotivate Engineering of Ningbo University of Technology,which are included in the innovation deepening pilot project in Zhejiang Province. A total of 200 questionnaires were distributed and 191 were retrieved, with a recovery rate of 95.5% and 182 valid questionnaires. There are 15 teaching managers in the survey, including teaching managers of secondary colleges and schools. Participants in the survey accounted for 81% of those with more than 15 years of work experience in colleges and universities, 58.7% of those with the title of deputy high school or above, and 41.3% of those with the title of intermediate level. Nine of all respondents had never supervised a practical session, and the rest had participated in at least one type of practical teaching activities. Therefore, the sample of this survey is representative.

Table 2 shows the results of reliability and validity analysis, by using SPSS20.0 to analyze the reliability of the questionnaire data, firstly, the overall Cronbach's alpha reliability test was conducted, and the result was 0.922, and then Cronbach's alpha reliability test was conducted for each level of indexes separately, and then the data was analyzed for validity by using KMO and Bartlett's test of sphericity. The results show that the reliability of the questionnaire is strong, indicating that this study is suitable for principal component analysis.

Table 2. Reliability and validity analysis results

Potential variable	Cronbach's Alpha	KMO	Bartlett
C1	0.9612	0.8813	0.0000
C2	0.9623	0.9236	0.0000
C3	0.8832	0.8634	0.0000
C4	0.8933	0.8861	0.0000
C5	0.8812	0.8933	0.0000
C6	0.8764	0.8746	0.0000
C7	0.9513	0.8612	0.0000
C8	0.9423	0.9136	0.0000
C9	0.9613	0.9266	0.0000
C10	0.9812	0.9135	0.0000
C11	0.8723	0.9034	0.0000
C12	0.8934	0.8833	0.0000

4.1.2. Descriptive principal component analysis. Fewer principal components with major features can be used to explain the differences in the data and prevent important information from being lost. Table 3 shows the factor loading matrix of the first 3 principal components. According to the principal components, modern industrial colleges are evaluated on the characteristics and event patterns of higher education institutions. According to the results of principal component analysis, it is known that the mean values of principal components 1, 2 and 3 are 0.27, 0.096 and -0.0186, respectively.

Table 3. Factor load matrix for the first 3 principal components

Number	Comp.1	Comp.2	Comp.3	Mean	S.D.
C1	0.3496	-0.0962	-0.1936	0.6063	1.0264
C2	0.2763	-0.0093	-0.4325	1.8364	0.7765
C3	0.1926	0.0815	-0.5624	0.1348	1.3169
C4	0.0249	0.7038	0.2645	1.0563	0.8064
C5	0.0954	0.6801	-0.1636	2.4064	0.4615
C6	0.3169	-0.0536	0.1678	0.2698	0.3836
C7	0.3648	0.0048	0.2769	0.3769	0.6245
C8	0.3248	-0.0295	-0.1966	1.3515	1.7654
C9	0.3596	-0.0065	0.3287	0.5632	1.0966
C10	0.2848	-0.1436	0.1256	0.5896	0.6132
C11	0.3093	0.0075	-0.1469	2.6912	1.9645
C12	0.3418	0.0165	0.3088	0.1799	0.3876

4.1.3. Means and standard deviations of transformed indicators. After standardization and logarithmic transformation of the 12 indicators, a new dataset is formed so that the mean, standard deviation and correlation results of each indicator can be calculated.

The mean value represents the concentrated trend of the data and can reflect the overall level of the indicators. Figure 2 shows the mean and standard deviation of the 12 indicators after transformation. In the figure, the three scores of modern industrial colleges with perfect teaching quality and support for construction, the proportion of innovation and entrepreneurship in school and graduation are the highest, which are 1.8348, 2.4366, and 2.6951, respectively, indicating that the integration of industry and education in modern industrial colleges pays attention to the local demand for industry and education and pays attention to the strengthening of ties with the region, and is able to make use of its own specialties in professional industry and education and play a certain role in the local industry, education and cultural undertakings. It has played a certain role in the local industry-education culture. At the same time, the graduates are highly recognized by the society, and the employers are positive about their professional skills and career level.

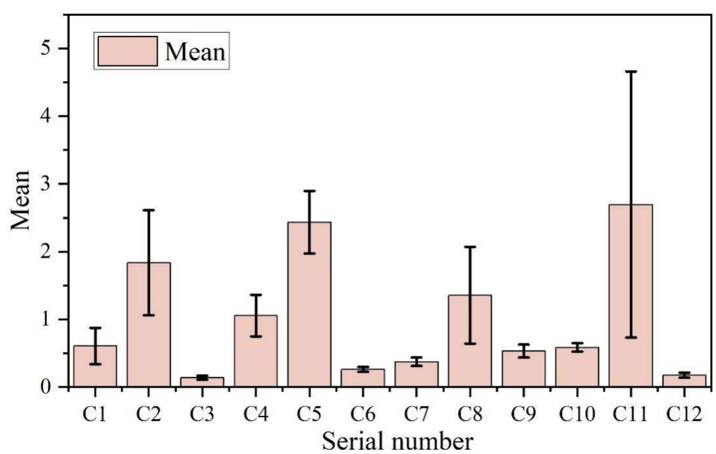

Fig. 2. The mean and standard deviation of the 12 indexes after the transformation

4.1.4. Correlation coefficient matrix. Matlab software is chosen to standardize the data, after the standardization is completed, the covariance matrix of the variables is established, etc., and then Matlab is used to carry out the principal component analysis to obtain the correlation coefficient matrix between the variables, and the correlation coefficient matrix is shown in Fig. 3.The figure describes the value of each indicator of each factor, and C1~C12 correspond to the influencing factors of the industry-teaching fusion and collaborative educating in the modern industrial colleges, respectively.The correlation coefficient can be analyzed to obtain that there is a correlation between variable factors, and Fig. 3 shows the correlation coefficient matrix can be analyzed to get that there is a correlation between the variable factors, and the correlation coefficient is in the range of -0.2736~0.9315. Therefore, principal component analysis can be used for modeling.

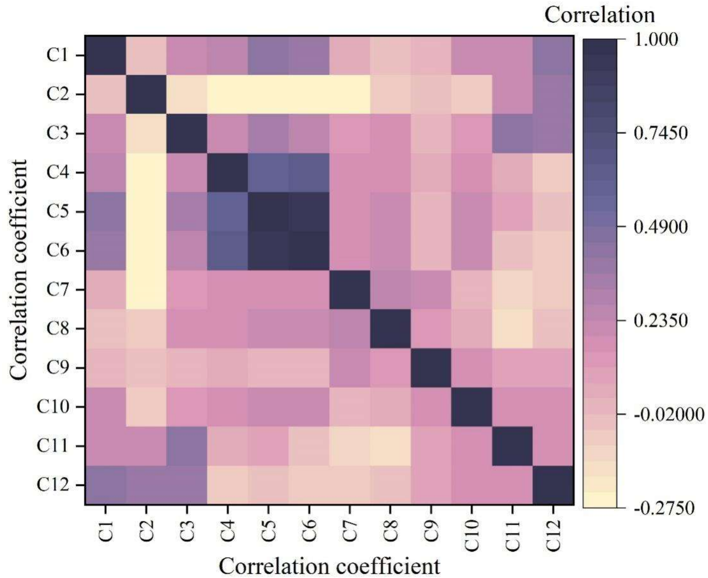

Fig. 3. Correlation coefficient matrix

4.1.5. Cluster analysis. Cluster analysis is mainly used in exploratory research, it is a statistical technique to classify the research object into relatively homogeneous groups, according to the similarity degree of modern industrial colleges of colleges and universities established by all the indexes, using systematic clustering method can be clustered into 1, 2 and 3 categories, which represent the low, medium and high levels of the integration of industry and education, respectively, Fig. 4 is the distribution of modern industrial colleges of three levels of integration of industry and education in 15 provinces. Figure 4 shows the distribution of modern industrial colleges in 15 provinces with three levels of industry-education integration. The figure shows that the proportion of institutions in category 1 and 2 is larger in Zhejiang, Jiangsu, Hunan, Hubei, Guangdong, Fujian and Shandong, etc. For example, the proportions of institutions in low, medium and high levels in Zhejiang are 28.57%, 28.57% and 42.86% respectively, which means that the modern industrial colleges in Zhejiang province have strong strength and obvious competitive advantages in industry-education integration.

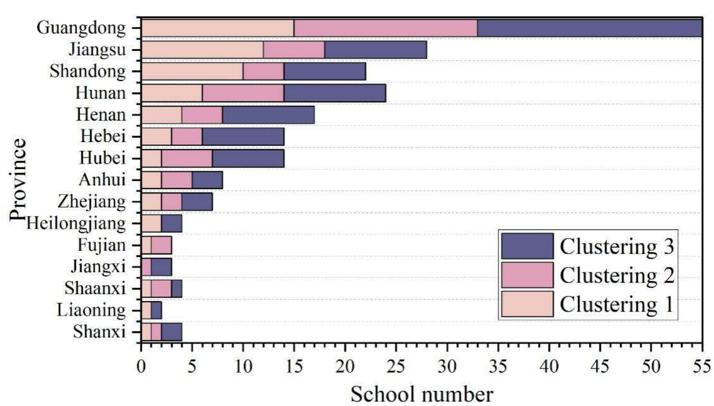

Fig. 4. The modern industry college of the integration level of production

4.2. Evaluation of the Quality of Industry-Education Integration in Modern Industrial Colleges

4.2.1. Quality Score of Industry-Education Integration in Modern Industrial Colleges of Higher Education Institutions. The evaluation results of the quality of industry-teaching integration in modern industrial colleges in Zhejiang Province are shown in Table 4. The score of education and teaching achievements of modern industrial colleges in Zhejiang Province is relatively low at 85.8439 points, which may be related to the current economic structure and industrial demand in Zhejiang Province. This may be related to the current economic structure and industrial demand of Zhejiang Province. It shows that there is a gap between the educational and teaching achievements and the expectations, which needs to be further optimized to meet the actual demand of industrial development in Zhejiang Province.

Table 4. Quality evaluation of production and teaching

Primary index	Mark	Secondary index	Mark
Talent cultivation quality	94.1904	Specialist assessment	95.0422
		Quality of teaching	92.5263
		Employment, professional correlation	98.8315
		The employer has high satisfaction with graduates	90.3615
Education results	85.8439	The modern industry college, which supports construction	87.6133
		Collaborative education	87.7612
		The results of the above teaching	93.6136
		The excellent teaching village above the provincial level	79.6156
		"Five groups" project	80.6158
Innovation and entrepreneurship	91.7288	Innovation and entrepreneurship education	93.0345
		The proportion of college and graduate innovation	93.7155
		In countries, provincial "challenge cup" series competition, etc., won the gold medal	88.4365

4.2.2. Heterogeneity analysis. The five provincial key modern industrial colleges, including the Modern Industrial College of Digital Manufacturing of Zhejiang University of Technology, the Modern Industrial College of Textile and New Materials of Zhejiang Sci-Tech University,the Industrial College of Ophthalmology and Optometry of Wenzhou Medical University,the College of Cross-border E-commerce of Zhejiang Gongshang University,the College of Hangzhou Bay Automotivate Engineering of Ningbo University of Technology,are represented by college A-E, and the quality of the integration of industry and education among modern industrial colleges is analyzed in terms of their heterogeneity.

The heterogeneity comparison of different modern industrial colleges in Zhejiang Province in the evaluation of the quality of industry-teaching integration is shown in Table 5. College A performs better in the quality of talent cultivation with a score of 85, but it is slightly deficient in the educational and teaching outcomes with only 75.College B performed well in all aspects and scored 85 points. College C scored 85 points for its excellent performance in terms of quality of human resources training, but was slightly deficient in terms of educational and teaching outcomes. College D's performance in education and teaching outcomes is average with a score of 70, which needs to be improved comprehensively. College E performed well in all aspects and scored 86.7 points. Therefore, for College A, it can be considered to improve the results of education and teaching, and strengthen the construction of faculty, in order to improve the overall score. College D likewise needs to invest more in educational outcomes. For College C, it is necessary to focus on the improvement of education and teaching outcomes and innovation and entrepreneurship outcomes.

Table 5. Heterogeneity analysis

Colleges and universities	Talent cultivation quality	Educational and teaching results	Achievements in innovation and entrepreneurship	Comprehensive score
College A	85	75	80	80
College B	80	85	90	85
College C	85	70	75	76.6667
College D	80	70	85	78.3333
College E	90	80	90	86.6667
Average score	84	76	84	81.3333

5. Optimizing the path of integration between industry and education

5.1. Optimization pathways at the environmental level

5.1.1. Promote policy synergies and establish a combined incentive policy system. As an institutional arrangement, the integration of industry and education involves many factors, and these factors are cross-field and cross-industry, involving government agencies, non-governmental organizations and industry associations, schools and enterprises, etc., and vertically involving the national, provincial and municipal governments, and horizontally involving the education sector, development and reform sector, human resources and social services, etc., so that there is a problem of fragmentation in the formulation and implementation of policies. In this context, the systematization and synergization of relevant policies have become an inevitable requirement and prerequisite for the development of urban industry-education integration.

5.1.2. Innovative talent evaluation and formation of a social culture of cooperation and innovation. Culture, as a soft environment for urban development, is also an important part of the ecosystem for the integration of industry and education. To this end, it is necessary to form a social culture that respects knowledge and talent and encourages innovation and entrepreneurship through an innovative talent evaluation system, shaping a culture of cooperation and building a social support system for innovation and entrepreneurship,in addition, through various publicity channels such as television, the Internet and social media, report on the successful cases of industry-education integration and the outstanding achievements of collaborative innovation.

5.2. Optimization path at the institutional level

5.2.1. Improvement of the common and shared mechanism to promote the effective conversion of resources. The integration of industry and education requires not only cultural integration, but also integration at the physical level. In this regard, it is necessary to take the city as a carrier to establish a physical-level resource-sharing mechanism to realize the sharing of industrial and educational resources.For example, a unified resource-sharing information platform for colleges and universities, enterprises, and scientific research institutions can be built. Colleges and universities can jointly build interdisciplinary laboratories, and enterprises and colleges and universities can jointly build internship and training bases, so as to promote the deepening development of the integration of industry and education

5.2.2. Innovative organizational forms and operational mechanisms to promote benign operation of industry-education integration. Industry-education integration is a process of collaboration among multiple subjects, and in order to promote resource sharing and balanced benefits among subjects, it is necessary to innovate the organizational form of industry-education integration from the following two aspects. First, establish a regional industry-education alliance centered on value co-creation.

Schools, enterprises, research institutes and relevant local governments (parks) in the city can set up regional industry-education alliances around the needs of regional industrial development, and carry out cooperation in professional and faculty construction, talent cultivation, scientific and technological innovation, and policy consulting in an organized manner, so as to buttress the professional group to the industrial group and the innovation chain to the industrial chain, and enhance the ability of industry-education integration to serve the development of regional industries.

The second is to organize industrial colleges with cross-body cooperation. Schools can form industrial colleges with an enterprise or multiple enterprises to carry out talent training by sharing school and enterprise resources to meet the talent needs of enterprises. Industrial colleges take specialties or assets as a link, implement in-depth cooperation between industries, enterprises and schools, efficiently integrate educational resources, complement each other's strengths, and establish a relatively independent operation mechanism and main body responsibility system.

6. Conclusion

This paper applies the CIPP model to the construction of the index system for evaluating the quality of industry-teaching integration and collaborative education in modern industrial colleges of universities. Based on the basic principle and mathematical model of principal component analysis, the index system layer is designed, the index system weights are established, and the quality of industry-teaching integration in modern industrial colleges is scored. Using descriptive analysis to parse the variability of the principal component data, the mean values of principal components 1, 2 and 3 are 0.27, 0.096 and -0.0186, respectively.At the same time, after matrix transformation, the modern industrial colleges that support the construction of the three scores for the proportion of innovation and entrepreneurship in school and graduation are the highest, which are 1.8348, 2.4366, and 2.6951, respectively.In the three layers of the integration of production and education, the Zhejiang Province, modern industrial colleges of education and teaching results score is relatively low at 85.8439 points, indicating that there is a gap between the education and teaching results and expectations, and the need to further optimize the structure of the integration of industry and education. Comparing the heterogeneity results in the quality evaluation of industry-teaching integration of modern industrial colleges in different colleges and universities in Zhejiang Province,it indicates that there are differences in the quality of the integration of industry and education among the five provincial key modern industrial colleges.The modern industrial college of the author's affiliated institution(the Industrial College of Ophthalmology and Optometry of Wenzhou Medical University) scored 85 points for its excellent performance in terms of quality of human resources training, but was slightly deficient in terms of educational and teaching outcomes.For the Industrial College of Ophthalmology and Optometry of Wenzhou Medical University, it is necessary to focus on the improvement of education and teaching outcomes and innovation and entrepreneurship outcomes.

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