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Construction of a Quality Evaluation System for Vocational Education Industry-Education Integration Based on AHP

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Abstract At present, the reform of vocational education is deeply promoted, and school-enterprise cooperation has become an important way to cultivate skilled talents. This paper constructs a quality evaluation system for the integration of industry and education in vocational education based on CIPP model and hierarchical analysis method. Through literature combing, questionnaire research and expert interviews, an evaluation system containing 4 first-level indicators and 14 second-level indicators for background evaluation, input evaluation, process evaluation and outcome evaluation is established. The study uses hierarchical analysis to determine the weight of each indicator, in which the process evaluation has the highest weight of 0.4128, followed by the outcome evaluation of 0.2849. 10 cases of education-industry integration are empirically analyzed using principal component cluster analysis, which shows that the similarity coefficients of each case are above 0.95, and the cluster analysis divides the cases into 3 categories. The study shows that the evaluation system can effectively identify the quality characteristics of the integration of industry and education, and provide a scientific evaluation tool and improvement basis for the practice of integration of industry and education in vocational colleges.

Index Terms Vocational education, integration of industry and education, quality evaluation, CIPP model, hierarchical analysis method, cluster analysis

I. Introduction

Talent cultivation quality evaluation plays a key role in guaranteeing the effectiveness of schooling and promoting the high-quality development of education [1]. Under the background of industrial transformation and upgrading, in order to adapt to and lead the development needs of emerging industries, cultivating high-quality composite skilled talents needed by the society is of great significance to enhance regional development [2], [3]. Higher vocational colleges and universities should insist on promoting production by teaching and assisting teaching by production, accelerating the formation of a development pattern of deep integration of production and education with benign interaction between production and education and complementary advantages of schools and enterprises, continuing to optimize the structure of human resources supply, and providing strong human resources support for the comprehensive construction of a socialist modernized country [4]-[7].

With the vocational education industry-education fusion entering a new stage of comprehensive deepening and quality improvement, the vocational education industry-education fusion has made a significant contribution to economic and social development around “empowerment” and “enhancement” [8], [9]. Some scholars have pointed out that the construction of pilot cities for the integration of industry and education can promote the high-quality development of vocational education, promote the transformation and upgrading of regional industries, and the talents cultivated by the cooperation between schools and enterprises can support the development of regional economy and society [10]-[12]. However, the quality of talent cultivation and the level of schooling effectiveness need to be measured by a sustainable and perfect evaluation system [13]. Therefore, sound comprehensive evaluation is of great significance to carry out all-round and whole-process evaluation of talent cultivation quality, promote diversified development of students, and comprehensively improve the effectiveness of talent cultivation.

This paper constructs a quality evaluation index system for the integration of industry and education based on the CIPP model, uses hierarchical analysis to determine the weights of the indexes at all levels, and verifies the evaluation system through principal component cluster analysis. Firstly, through literature analysis and field research, the key elements of the quality evaluation of the integration of industry and education are clarified; secondly, based on the framework of the CIPP model and following the stakeholder theory, a multi-level evaluation index system covering the background, inputs, processes and results is constructed; again, the hierarchical analysis method is applied to determine the weights of the indicators through expert scoring; finally, typical cases of the integration of industry and education are selected, and the evaluation system is validated by principal component cluster analysis. Finally, a typical case of industry-education integration is selected to verify the effectiveness and practicality of the evaluation system by using principal component cluster analysis.

II. Construction of Quality Evaluation System for Vocational Education Industry-Teaching Integration Based on CIPP

II. A. Applicability of CIPP model and quality evaluation of industry-teaching integration

The integration of industry and education is actually a multi-dimensional and multi-level cross-border matrix cooperation mechanism. The evaluation of the quality of the integration of education and industry should not only focus on the background, status quo, and goals of the cooperation between schools and enterprises, but also pay close attention to the depth of mutual integration and the process of co-construction and coexistence between the two sides, the results of mutual integration and co-construction between schools and enterprises and the degree of achievement of the interests of all parties, and pay more attention to the subjective cognitive emotions of the evaluated individuals, as well as the development and improvement of their situation.

CIPP model [14] can carry out systematic evaluation from the space, time and value dimensions of the integration of education and industry through the four dimensions of background evaluation, input evaluation, process evaluation and result evaluation, and design the quality factors such as the interests of the school and the enterprise, the resource conditions, and the objectives, process, results and balance of the interests of all parties and the development of the quality factors in the quality evaluation model.

The quality evaluation model of industry-teaching integration based on CIPP is shown in Figure 1. The evaluation model carries quality evaluation through the whole process of mutual integration and many links, integrates diagnostic evaluation, formative evaluation and result evaluation organically, expands the scope and content of evaluation, highlights the developmental function of evaluation, and ensures the relevance, improvement and sustainability of the evaluation system. It can be seen that the CIPP model is more suitable for the quality evaluation of the integration of education and industry because of its systematic, pertinence, improvement and developmental characteristics.

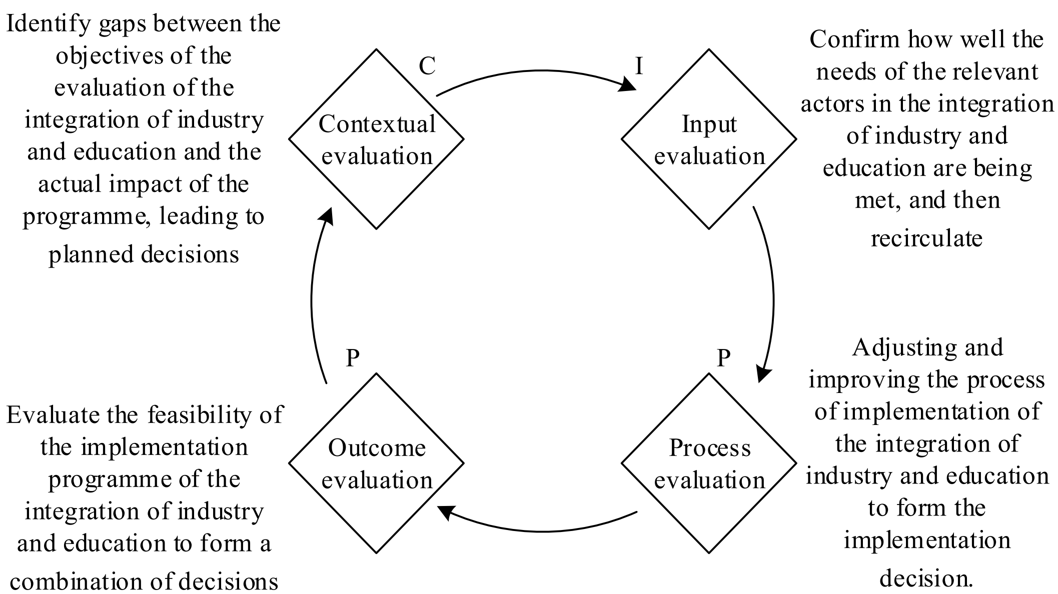

Figure 1: Based on CIPP's production and teaching fusion quality evaluation model

II. B. Construction of quality evaluation index system for industry-teaching integration

II. B. 1) Principle Setting of Evaluation Indicator System Construction

(1) Adhere to the principle of balancing the effectiveness of school and enterprise interests. One of the reasons for the slow development of the integration of industry and education [15] over the years is that in the absence of encouraging policy support, the interests of schools and enterprises cannot be fundamentally guaranteed. When designing the evaluation index for the integration of industry and education, we should consider the principle of balancing the effectiveness of schools and enterprises, i.e., it is suggested that schools and enterprises should be evaluated in a synchronized manner in order to guide the two sides to share the responsibility and promote the maximization of their respective benefits.

(2) Adhere to the principle of dynamic development of the process of industry-education integration. After reaching a consensus on the cooperation of industry-industry integration, schools and enterprises will focus on the main line of cooperation and mutual integration and co-construction, and through a series of mutual integration and co-construction activities, such as "setting standards, reviewing programs, constructing curricula, training teachers, building platforms, researching projects, integrating cultures and educating talents", we will explore the deep integration with enterprises in the five dimensions of cultivation standards, content system, conditions and resources, teaching and research, and evaluation and feedback. Explore the in-depth integration with enterprises in five dimensions: cultivation standards, content system, conditions and resources, teaching and research, and evaluation and feedback, so as to realize the docking of professional settings with industrial demand, curriculum content with occupational standards, and teaching process with production process, and to facilitate the high-level development of the school.

(3) Adhere to the principles of evaluation systematicity, scientificity and operability. Indicators need to be designed with reference to systematics and scientific methods and reasonably constructed with the help of tools. The evaluation indicators should evaluate both the background and cooperation conditions of the two sides, as well as the process and results of the cooperation between the two sides.

II. B. 2) Selection of evaluation indicators

The members of the research group conducted a questionnaire survey in 30 vocational colleges and universities across the country, and the targets of the survey were mainly the heads of secondary colleges and universities, professional leaders, as well as the heads of teaching and support departments and functional departments that are closely related to the professions. Combined with the results of the research, the members of the group organized a series of interviews with experts and sorted out the related literature and policies again. Finally, the results of the research and interviews, the national policies and the results of the literature sorting were integrated, and based on the theory of stakeholders, the indicator system containing 4 primary indicators and 14 secondary indicators was designed for the identified stakeholders such as students, teachers, schools, enterprises and so on in the activities of cooperation and co-construction.

The background evaluation mainly evaluates the relevant background of the school and enterprise, social reputation, etc., as well as the industrial background of the specialty, the trend of talent demand in the industry and the connectivity, etc. The input evaluation mainly evaluates the ability of the two parties to effectively and efficiently implement the program.

Input evaluation mainly collects information and carries out feasibility assessment on the resources that both sides can actually and effectively invest in such as teachers, projects, experimental equipment and environment, as well as the improvement of the management mechanism of the integration of industry and education of both sides, in order to determine the optimal resources and conditions for the implementation of the cooperative construction program.

Process evaluation mainly supervises, records and evaluates the series of activities in the process of cooperation and joint construction, including the demonstration and formulation of talent cultivation programs, the construction of courses and software and hardware teaching resources.

Outcome evaluation mainly centers on the four links of "goal-planning-implementation-results" to form a logical closed loop, and evaluation feedback is carried out throughout each link.

II. B. 3) Connotation of indicators for evaluating the quality of industry-teaching integration

The quality evaluation index of the integration of industry and education based on the CIPP model, on the one hand, fully takes into account the individual growth and needs of the school teachers, students, enterprise employees and other relevant stakeholders involved in the integration of industry and education, and on the other hand, it actually takes the stakeholders of the school and the enterprise as the logical framework, stands on the perspective of the overall interests of the relevant participants, and comprehensively evaluates the expected benefits of the stakeholders in the process of the integration of industry and education. On the other hand, it takes the perspective of the overall interests of the relevant participants and comprehensively evaluates the expected benefits of each stakeholder in the process of University-Industry Integration, reflecting that the evaluation should take the realization of the value of the participants' lives as the ultimate goal as emphasized by stakeholder theory. The quality evaluation indicators of the integration of industry and education are shown in Table 1.

Table 1: The evaluation index of the quality of the production

Primary indicator	For short	Secondary indicator	For short
Evaluation background	A	Industry background	A1
		Industry impact	A2
		Social recognition	A3
Input evaluation	B	Conditional resources	B1
		Building mechanism	B2
		Building course	B3
Process evaluation	C	Mutual cultivation of teachers	C1
		Common research project	C2
		Mutual cultivation	C3
		Talent cultivation quality	C4
		Common platform	C5
Achievement evaluation	D	Professional materialization	D1
		Social service benefits	D2
		Cooperative technology or product benefit	D3

II. C.Hierarchical Analysis

The hierarchical analysis method (AHP) is a commonly used way of constructing indicators. Hierarchical analysis has been widely used in the current research on quality assessment of industry-teaching integration in vocational education. The general steps of this method are, firstly, to stratify the factors included in the problem into the highest, middle and lowest levels. Secondly, a comparison matrix is constructed, then weights are calculated and finally a consistency test is performed. If the consistency test is not passed, then the weights are recalculated after adjusting the comparison matrix again until the consistency test is passed.

First of all, in the assessment of the quality of the integration of vocational education and industry, each sample of the first level indicator of the first level index score is the highest level, and various indicators related to the first level indicator, such as the industry background and industry influence, are the middle level, and all the samples constitute the bottom level.

Secondly, a comparison matrix is constructed to subjectively compare the relative importance between each two indicators, if n indicators are shared, a matrix of $n \times n$ will be obtained. The element a_{ij} in the matrix represents the importance of indicator i relative to indicator j, and the value is generally an integer between $1/9$ and 9 or a unit fraction with an integer as the denominator, in which the integer or the denominator is mostly odd, supplemented by an even number, and the larger the value is, the more important the indicator i is relative to indicator j. In general, if $a_{ij} = N$, then $a_{ji} = 1/N$. To wit:

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

The weights of the indicators are then calculated with the following formula:

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

Finally, the consistency test is performed by first calculating the maximum eigenvalue:

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n} \frac{\sum_{j=1}^{n} a_{ij}\omega_j}{\omega_i} \tag{3}$$

Finally, the consistency test is performed by first calculating the maximum eigenvalue:

$$CR = \frac{\lambda_{\max} - n}{RI(n-1)} \tag{4}$$

In the formula, RI denotes the value of the correction of degrees of freedom, which is related to the number of indicators n, the larger n is, the larger RI is. When CR does not exceed 0.1, it can be considered to have passed the consistency test. If it exceeds 0.1, the comparison matrix has to be adjusted and the weights have to be recalculated until the consistency test is passed.

Finally, the credit score of each enterprise is:

$$credit = \sum_{i=1}^{n} \omega_i x_i \tag{5}$$

where x_i represents each indicator after standardization. The higher the score, the lower the index at the enterprise level.

Same as the expert judgment method, the selection of indicators and the relative importance between indicators of hierarchical analysis method are also determined by experts, but the difference is that the hierarchical analysis method can quantify the weight of each indicator, and the selection of indicators can be more widely and flexibly, which means that the selection of indicators with higher degree of objectivity and quantification can be selected, and the first-level indicators of different enterprises can be quantified finally. However, its disadvantage is still too much subjectivity.

III. Design and realization of a quality evaluation system for the integration of industry and education in vocational education

III. A. Determination of the weights of indicators for evaluating the quality of industry-teaching integration in vocational education

After determining each indicator, the indicator system also needs to determine the importance of each indicator in the evaluation process and reflect it through the indicator weights. Therefore, the study utilizes the hierarchical analysis method to transform the expert scores into the weights of each indicator, and constructs a complete indicator system for evaluating the quality of industry-teaching integration in vocational education.

III. A. 1) Hierarchical modeling

According to the AHP operation steps, combined with the quality evaluation index system of the integration of industry and education in vocational education constructed above, the index system is divided into four layers, that is, the target layer of the quality of the integration of industry and education in vocational education, including the "background evaluation, input evaluation, process evaluation and achievement evaluation" of the quality of integration of industry and education. The background evaluation of the first-level indicators includes "industry background, industry influence and social recognition"; The input evaluation includes "conditional resources, co-construction mechanisms and co-construction courses"; The process evaluation includes "co-training teachers, co-training platforms, co-research projects, co-cultivating talents and talent training quality"; The evaluation of the results includes "professional materialization results, social service benefits, and cooperative technology or product benefits". There are a total of 14 secondary indicators.

III. A. 2) Constructing two-by-two judgment matrices and indicator scores

Based on the vocational education industry-teaching integration quality evaluation index system developed in the previous stage and passed the reliability and validity test, a weighted questionnaire was prepared, which contained four parts: the header, instructions for filling in the questionnaire, examples, and an expert rating form, and was then distributed and recovered. The data in the recovered expert rating form were transformed into a judgment matrix based on the hierarchical relationship. According to the scoring of the importance of the first-level indicators, the results of the weight vector, the CR value is less than 0.1, that is, they all pass the consistency test. Therefore, the expert scoring matrix can be constructed. Combined with the expert weights, the final weights of each level and indicator are sought.

III. A. 3) Hierarchical ranking of indicator weights and consistency test

The weights of the indicators at each level are shown in Table 2, and among the first-level indicators, process evaluation has the greatest weight, followed by outcome evaluation and input evaluation, and background evaluation has the lowest weight; the corresponding weights of the four indicators are 0.1257, 0.1766, 0.4128, and 0.2849, respectively. Among the secondary indicators, the combined weights of the four indicators of “common platforms, social service benefits, joint research projects and benefits from cooperative technologies or products" are all greater than 0.1, and the combined weight of industry background is the lowest at 0.0172. Except for the four indicators with combination weights > 0.1, the combination weight values of the remaining indicators range from 0.0172 to 0.0914.

The weight of each indicator calculated in this paper will represent the importance of that indicator in the whole quality evaluation index system, which is involved in the calculation of the quality of the integration of industry and education in the case institutions. Among them, the CR of each expert's scoring matrix for each level takes the range of 0-0.0876, which is less than 0.1, and passes the consistency test, i.e., this version of the indicator weights is reasonable and effective.

Table 2: The weight of indicators at all levels

Primary indicator	Weight	Secondary indicator	Composite weight
Evaluation background	0.1257	Industry background	0.0172
		Industry impact	0.0645
		Social recognition	0.0405
Input evaluation	0.1766	Conditional resources	0.0785
		Building mechanism	0.0523
		Building course	0.0488
Process evaluation	0.4128	Mutual cultivation of teachers	0.0914
		Common research project	0.1625
		Mutual cultivation	0.1123
		Talent cultivation quality	0.0269
		Common platform	0.0185
Achievement evaluation	0.2849	Professional materialization	0.05
		Social service benefits	0.1288
		Cooperative technology or product benefit	0.1078

III. A. 4) Analysis of the weights of the evaluation indicator system

(1) Process evaluation is more emphasized in the first-level indicators.

The first-level indicators contain a total of four dimensions: background evaluation, input evaluation, process evaluation, and outcome evaluation. Among them, the weight of the process evaluation dimension is 0.4128, accounting for the largest proportion. The second is the outcome evaluation, with a weight of 0.2849. From the results of the experts' scoring, the experts relatively attach more importance to the implementation process of the integration of industry and education. The reason for this is that as a comprehensive education system, the effect of education has a lag, and most of the initiatives in the process evaluation process do not bring direct benefits. However, in practice, these initiatives promote the current cooperation process and provide a guarantee for the quality of education. Therefore, the process evaluation was unanimously emphasized by the experts. In addition, the weight of the outcome evaluation dimension is also relatively large, and the cooperation outcome, as the most direct display of results, rightly becomes an important factor in the evaluation of the quality of the integration of industry and education. Background evaluation and input evaluation have relatively less weight, but they are still indispensable factors in the quality evaluation of the integration of industry and education. Vocational education, as a type of education with high educational costs, cannot be ignored. Similarly, the input evaluation in the integration of production and education is also an important influence on its quality, with a weight share of 0.1766. The weight share of the background evaluation is relatively minimal, at 0.1257.

(2) The weight of the secondary indicators is more in the category of social service benefits.

The secondary indicators with higher weights are all core initiatives or important results of the integration of industry and education. They not only involve multiple dimensions of process evaluation and outcome evaluation, but also reflect the talent cultivation of the school and the economic benefits of enterprises, taking into account the interests of both sides.

III. B. Validation Methods of the Quality Evaluation System of Vocational Education Industry-Teaching Integration

In this study, principal component cluster analysis is used to validate the evaluation system of higher vocational talent training quality. Principal component analysis refers to screening out key variables among many variables, eliminating irrelevant or low proportion variables, thus reflecting the original characteristics of the data, and ranking the samples according to the principal component scores; cluster analysis refers to clustering the samples among the screened key variables and ranking the sample clusters, so as to obtain the essential characteristics of the data. The specific steps include six aspects.

(1) Data standardization processing

The original data are obtained through the research, but because the original data often differ significantly, which can cause the data to be significant, so in order to make the obtained data mapped to a uniform dimension, the standardization processing formula is quoted, and the formula is as follows:

$$X_{ij}^{*}=\frac{X_{ij}-\bar{X}}{S_j},i=1,2,\cdots,n;j=1,2,\cdots,p \tag{6}$$

where X_{ij}^{*} denotes the standardized variable, X_{ij} denotes the original variable, $\bar{X}$ denotes the variable mean, and S denotes the variable standard deviation.

(2) Construct the sample correlation coefficient matrix

The correlation coefficient matrix is derived from the covariance results with the following formula:

$$R=(r_{ij})_{p\times p};r_{ij}=\frac{S_{ij}}{\sqrt{S_i}\sqrt{S_j}} \tag{7}$$

where R is the correlation coefficient matrix, S_{ij} is the covariance of X_i and X_j, and S_i and S_j are the variances of X_i and X_j respectively.

(3) Calculate eigenvalues and eigenvectors

Based on the eigenvalue formula, find the eigenvalues of the correlation coefficient matrix, $\lambda_1,\lambda_2,\cdots,\lambda_q$, and the eigenvectors $\mu_i=\left\{\mu_{i1},\mu_{i2},\cdots,\mu_{ip}\right\}$.

(4) Screening principal component variables

Calculate the variance contribution rate and cumulative variance contribution rate α_i of the principal components to the original indicators with the following formula:

$$\alpha_i=\frac{\lambda_i}{\sum_{i=1}^{p}\lambda_i},i=1,2,\cdots,n \tag{8}$$

where λ_i is the eigenvalue, when the cumulative variance contribution ratio is greater than or equal to 85% and $\lambda_i>1$, the number of principal components m can be derived, and the first m variables are taken as principal components.

(5) Calculate the principal component score

The feature vector $\mu_i=\{\mu_{i1},\mu_{i2},\cdots,\mu_{ip}\}$ is computed through the above steps and is substituted into the following formula together with the existing index $X_p=\{X_1,X_2,\cdots,X_p\}$:

$$F_i=\mu_{i1}X_1+\mu_{i2}X_2+\cdots+\mu_{ip}X_p(i=1,2,\cdots,m) \tag{9}$$

Constructing the assessment function of senior talent training quality based on m principal component variables:

$$F_i=\alpha_1X_1+\alpha_2X_2+\cdots+\alpha_mX_m \tag{10}$$

(6) Perform cluster analysis

The m variables screened out ahead were used as the new original data, and the new data were subjected to cluster analysis. Based on the principal component scores, the Euclidean distance formula was introduced:

$$d_{ij}=\sqrt{\sum_{k=1}^{m}\left(X_{ik}-X_{jk}\right)^2} \tag{11}$$

Denote the distance between X_i to X_j by d_{ij}, calculate the distance between each sample that is to get the distance proof $D=(d_{ij})_{m*n}$, use the shortest distance method to perform the cluster analysis, and denote the distance between G_p class and G_q class by D_{pq}, then:

$$D_{pq}=\min\{d_{ij}\} \tag{12}$$

Taking the project leader's unit as an example, based on the m principal component scores of each department, those with similar talent cultivation quality levels are grouped into one class, the average principal component scores in each class are calculated, and the inter-class ranking is performed based on the high and low scores, and then the quality of each department's talent cultivation is ranked, in order to evaluate the strengths and weaknesses of the departments under the mechanism of balancing supply and demand of talent cultivation by industry-education synergy and to put forward improvement measures.

III. C. Implementation of the quality evaluation model algorithm for the integration of industry and education

The quality evaluation index of the integration of industry and education established above is the initial work of the quality evaluation system of the integration of industry and education, and this evaluation index is applicable to each case of the integration of industry and education. The quantitative scoring of different cases of integration of industry and education in the same university according to this evaluation index can simply and intuitively get the quality effect of different cases, but this single evaluation method can not comprehensively reflect the comparison and connection between different cases of integration of industry and education. Therefore, we adopt cluster analysis algorithm to score the 10 cases of integration of education and industry reported by previous researchers according to the four quality evaluation indexes of integration of education and industry determined earlier, and then use SPSS software to conduct cluster analysis.The scoring results of integration of education and industry instances are shown in Table 3.The results show that the differences in the scoring results of the 10 cases in the four dimensions of contextual evaluation, input evaluation, process evaluation and result evaluation are relatively small, and the Different cases have a focus on the ratings in the four dimensions. For example, Case 2 is more focused on the background and outcome evaluations, and the input and process evaluations are relatively low.

Table 3: Results of the result of the fusion instance of the production

Actual case	A	B	C	D
Case 1	17.56	16.29	15.19	17.08
Case 2	19.96	14.34	15.45	17.06
Case 3	16.28	19.46	17.08	18.68
Case 4	16.19	15.17	14.91	15.37
Case 5	16.14	19.7	15.41	15.95
Case 6	16.26	15.26	14.83	15.56
Case 7	17.13	15.51	14.35	18.2
Case 8	16.65	19.71	16.01	17.25
Case 9	15.69	15.7	14.61	18.39
Case 10	19.58	15.94	17.25	19.37

The establishment of fuzzy similarity matrix is carried out on the above data: In this case, the similarity coefficient is calculated by taking the cosine of the angle,and the calculation process is realized by the statistical analysis software SPSS.The results of similarity matrix are shown in Table 4. The results show that the similarity coefficient values between the 10 samples are above 0.95, indicating a strong correlation between the cases.

Table 4: Similar matrix results

Case	1	2	3	4	5	6	7	8	9	10
1	1									
2	0.9927	1								
3	0.9956	0.9831	1							
4	0.9825	0.9987	0.9934	1						
5	0.9918	0.9825	0.9978	0.9887	1					
6	0.9987	0.9889	0.9929	1	0.9889	1				

7	0.9957	0.9954	0.9937	0.9906	0.9918	0.9908	1			
8	0.9948	0.9835	0.9997	0.9923	0.9981	0.9941	0.9931	1		
9	0.9936	0.9916	0.9949	0.9875	0.9924	0.9894	0.9996	0.9948	1	
10	0.9944	0.9811	0.992	0.997	0.9853	0.9971	0.988	0.9906	0.9887	1

The dynamic clustering results of the quality model of industry-education integration are shown in Figure 2. According to the dynamic clustering diagram, the classification of the quality of industry-education integration into three categories is as follows: {1,7,2,6}; {5,10,3}; {4,6,8}. Practical significance of cluster analysis for the quality evaluation of industry-education integration: The principle of cluster analysis is that the more samples are clustered into a class first, the more similar they are, and Table 3 in this example shows the model similarity coefficient. From the dynamic clustering process, it can be seen that when clustered into three categories, samples 1, 7, 2 and 6 of the first class all have higher scores in "industry-education integration talent training environment", and samples 2 and 6 are more similar. The second type of samples 5, 10, and 3 had a slightly lower evaluation score for the "effect of industry-education integration cooperation" and a higher evaluation score for "industry-education integration cooperation process", and 3 and 10 were more similar. The three types of samples 4, 6 and 8 have better evaluation scores for "enterprise quality of integration of industry and education" and "cooperation effect of integration of industry and education", while 6 and 8 are closer. Through cluster analysis of different samples, we can find out the common or similar characteristics of enterprises clustered in one category relative to universities, so as to provide data support for seeking more industrial integration in the future.

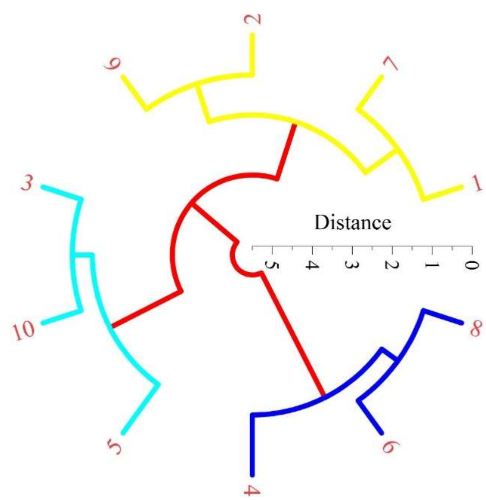

Figure 2: The result of the dynamic clustering of the mixed quality model

IV. Conclusion

The quality evaluation system of industry-teaching integration constructed in this study effectively solves the problem of monitoring the quality of school-enterprise cooperation in vocational education. The evaluation system consists of 4 level 1 indicators and 14 level 2 indicators, which comprehensively covers all aspects of industry-teaching integration. The weighting analysis shows that the process evaluation accounts for 0.4128 in the first place, reflecting that the expert group attaches great importance to the quality of the cooperation process; among the secondary indicators, the weighting of joint research projects reaches 0.1625, indicating that scientific research cooperation is the core element of the integration of industry and education. In the empirical analysis, the clustering results of the 10 cases of industry-teaching integration clearly present three typical patterns, which provide reference for different institutions to choose the cooperation path. The CR value of the consistency test of the evaluation model is less than 0.1, which proves that the index system has good internal consistency and scientificity. The evaluation system provides an operational tool for vocational institutions to carry out quality monitoring of the integration of industry and education, which helps to promote the school-enterprise cooperation to develop in depth and improve the quality of cultivation of technical and skilled talents.

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