The Construction of Evaluation Indicators for the Integration Degree of Industry and Education in Higher Vocational Colleges, Led by the New Quality Productive Forces Development Strategy

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Abstract: *With the spread of new quality productive forces, the problem for the industry-education integration system of higher vocational colleges is that the speed of technological change has risen and the knowledge half-life has been shortened. The old model of linear cooperation is based on equipment sharing and internship placement, and it can no longer meet the demand for dynamic matching. Due to the non-linear coupling characteristics of the integrated system, this paper puts forward a three-layer structure-strategy synergy, resource exchange, performance feedback mechanism and their development path. It can be seen that the three kinds of evaluation are based on integration density, depth and elasticity. According to the three main threads of the speed of technological iteration, reconstruction of production factors and transformation of industrial forms, this paper derives indicators for adaptability (technology response delay, knowledge coverage deviation), synergy degree (coding conversion rate, joint usage coefficient, role overlap index), and value-added capacity (skill transfer breadth, anomaly handling efficiency, process contribution rate, implicit cost reduction coefficient). Based on the four levels of classification for the degree of integration (from loose contact to ecological symbiosis), assign corresponding weights, build a composite index nonlinear synthesis model and a dynamic calibration mechanism, and then quantify the level of industry-education integration and hierarchically evaluate it.*

Keywords: *New Quality Productive Forces, High Vocational Colleges, Degree of Industry-Education Integration, Evaluation Indicators, Integration Maturity, Composite Index*

Introduction

The degree of industrial-educational cooperation will directly affect how well the talents produced by higher vocational colleges meet the needs of the industry. With the addition of new high-quality productive forces, there have been changes in the technical standards and process logic of the industry. The defects of the traditional linear collaboration and static resource-sharing model are becoming more and more serious, and now there is an urgent need to build an evaluation tool for the degree of integration that can reflect the quality of dynamic matching and the efficiency of system evolution. Most of the current evaluation methods only consider the scope of cooperation and the amount of resources; they have not accounted for how integrated behaviour affects the spread of technical knowledge. They do not consider the many levels of interaction effects or the different speeds of technological progress. Based on the logic of technical skill training, this paper studies the theoretical concept and attributes of integration degree. Based on the three main threads of technological iteration, factor reconstruction and form transformation, a domain-specific indicator framework will be established, and then a calibratable evaluation model will be constructed by combining weights and forming a composite index to quantify integration deficiencies and optimise resource allocation.

1. Theoretical Connotation and Dimensional Deconstruction of the Industry-Education Integration Degree under the Guidance of New Quality Productive Forces

1.1 The Embedding Logic of New Quality Productive Forces Factors in the Industry-Education Integration System

The characteristics of the new quality productive forces are data-driven technologies, intelligent production bases and network organisations. Their inclusion in the industry-education integration system of higher vocational colleges is not the simple addition of resources; rather, it is achieved by altering the carriers of knowledge and the path of transmission for technical skills. The main links between traditional industries and education are generally equipment sharing and internship places. With the addition of new quality-oriented factors of production, the system of integration will no longer be linear cooperation but nonlinear coupling. With the rapid pace of technological change and the short life of knowledge, education and industry need to adapt more quickly in terms of thinking. At the core of the above embedding logic is the conversion method for production factors into teaching factors. That is to say, before these can be used as effective input for the integration system, the technical standards, process parameters and procedural logic in the industry need to be pedagogically reconstructed[1].

The construction of the embedding process is in the form of two types of intermediary carriers: the first is a technical intermediary, such as a digital twin platform or an industrial Internet interface, that connects the flow of real-time data from the production site to virtual tasks in teaching; the second is an organisational intermediary that includes cross-departmental project teams and technology transformation nodes and is responsible for coordinating ownership and transformation paths of intellectual property. Together, the two kinds of intermediaries are the channels through which factors of new quality productive forces enter the education system from the industry side, and they affect both the speed and accuracy of the response of the integration system. The Degree of smoothness of the channels is directly related to the time lag in the update of technology and curriculum in the industry-education integration system. The smaller the time lag here, the more efficient the execution of the embedding logic will be.

1.2 The Multi-level Structure of the Industry-Education Integration Degree and its Evolution Mechanism

The degree of industrial-educational integration is not a single, measurable index; rather, it is a multi-level system that includes the level of strategic cooperation, the stage of resource sharing and feedback, etc. The Strategic Synergy Layer shows the extent of agreement between high vocational colleges and enterprises on the goals of talent cultivation, directions for technology research and development, priorities in resource allocation, etc. Set the Direction for the whole system in this layer. The four functions of the resource-sharing module are staff mobility, equipment sharing, data interoperability and joint ownership of intellectual property. How often and to what extent these contacts occur are the first signs of integration. The performance feedback layer will determine how the combined behaviour affects the development of competencies for technical and skilled employees, and how well technical problems can be solved by the industrial side to form a closed-loop regulation system.

Over the years, the coupling among these many links has gradually been strengthened, and the reasons for this are an increase in the complexity of technology and an expansion of the division of labour. At first, most of the cooperation was in the form of short-term collaborations for individual projects or personal connections, and this structure was loose and changed easily due to staff turnover. With the rapid development of technology, the demands of the industry for talents with certain combinations of skills are rising, so educational institutions have had to adjust the structure of their professional groups and curriculum modules to gradually reveal the strategy of synergy at this level. At the same time, the resource-exchange layer will also be bidirectional and not only have a one-way supply. For example, the need for process optimisation in the industry can be directly turned into project tasks at the teaching level, and the research and development results obtained through teaching can be used to improve the production line. Based on the above evolutionary mode, the progress of the degree of industry-education integration is not uniform; rather, there are stages at each level after reaching a certain threshold[2].

1.3 The Value Orientation and Core Category Definition of the Integration Degree Evaluation

The values used to assess the degree of integration should be in line with the essential requirements of the logic for cultivating technical skills and should not be determined solely by collecting external evaluation indicators. Different from the measurement of the general level of school-enterprise cooperation, the evaluation of the degree of industry-education integration focuses on how close the structural connection between the education system and the industry system is and how well it explains the adaptive output of talents. A change in the direction of values will cause the evaluation tool to give more weight to quantifiable contract numbers or equipment values and ignore the actual effect of integration behaviour on the process of technical knowledge reproduction. Therefore, in evaluating the extent of integration, it should be decided that the evaluation object is "the operational efficiency of the integration system" rather than "the coverage of cooperative activities"; the former refers to the quality of dynamic matching, and the latter focuses on the stock of static resources.

The three dimensions of the definition for the main categories are integration density, integration depth and integration elasticity. Integration density is the number and type of effective interaction events between higher vocational colleges and the industrial side per unit of time, and it shows the level of system activity. The degree of integration is the amount of technical knowledge employed in an interaction event, and it can be divided into three levels: transfer of operating skills, optimisation of process parameters, and development of original technologies. Integration elasticity is the system's capacity to maintain good performance in the face of technological changes and fluctuations in market demand; that is, how quickly the curriculum system can be adjusted and the cross-domain adaptability of teaching staff. The three dimensions mentioned above form the basis of the category framework for the integration degree evaluation, and the next step is to set operational definitions and measurement boundaries for the indicator system in this framework.

2. Selection and Hierarchy of Evaluation Indicators for the Degree of Industry-Education Integration at Higher Vocational Colleges

2.1 Design of Integration Adaptability Indicators Based on the Speed of Technological Iteration

The speed of technological iteration refers to how often changes are needed in the necessary processes or operating norms of a particular vocational field; thus, it directly affects the time lag in synchronisation of teaching content at higher vocational colleges with the demands of the industry. The Design of the integration adaptability indicators should be based on the two main reasons for the "technology response delay" and "knowledge coverage deviation". Technology response delay is the time taken from the introduction of a new process at the industrial level to the completion of updating the corresponding curriculum module at the teaching level. The shorter this period is, the more lenient it will be. Knowledge coverage deviation is the difference between the coincidence rate and the redundancy rate of the job skill list in the industry and the graduation requirements of schools. A small match rate indicates that the training goal is far from the actual situation in the industry; otherwise, it would be too simple[3].

Observation of adaptation indicators should have different measurement scales for different levels of the speed of technological iteration. High-frequency iteration fields, such as the control programs for industrial robots and simulation parameters in digital twins, have an adaptability index that depends on how modular the teaching materials are and how quickly they can be organised; that is to say, it includes the proportion of replaceable modules in the curriculum content and how often the teaching team can complete technical training per unit of time. For low-frequency iteration fields, such as the basic mechanical processing technology, the adaptation index is based on the stability of operating accuracy and the number of standard working hours. The different indices of the two types of fields show that the degree of integration adaptability is not fixed but relative, and it will change with the development of technology. The gap coefficient between early adopters and laggards in the technology diffusion curve is also used to correct for bias in the measurement of adaptability caused by internal technological differentiation at the industrial level in the construction of this index.

2.2 Extraction of Integration Synergy Degree Indicators for the Reconstruction of Production Factors

Reconstruction of production factors refers to the rearrangement and distribution of functions for the three types of factors in the industry-education integration system: labour, technical data and organisational processes. The degree of synergy is the product of the two components of the direction of factor flow and the efficiency of factor transformation. The direction of factor flow refers to whether there is any interaction at all among the paths of technical knowledge, operational specifications and problem contexts between higher vocational colleges and the industrial side. One-way flow (e.g., only the industrial side delivers equipment to the school and there is no technical feedback from the school) has a low degree of synergy. The efficiency of the factor transformation index is how quickly process data from the industrial side can be converted into actual technical solutions for that industry after pedagogical processing. The higher this proportion is, the more self-reinforcing the synergy system will be[4].

The three operating indicators for the synergy degree are as follows: First, the conversion rate of technical knowledge coding is the ratio of tacit operational experience provided by the industrial side that has been systematised into teaching documents and returned to the industrial side for use; Second, the joint usage coefficient of equipment and data resources shows both the time allocation weight and the cross-utilization rate of the same production equipment or the same set of process data in teaching activities and production activities; Third, the overlap index of personnel roles calculates the proportion of people involved in both teaching activities and technical development tasks at the industrial side out of the total teaching staff, as well as the depth of the hierarchy at which these individuals participate in technical decision-making. The three factors are not independent; they are related. A system with a high degree of synergy will have all three supporting indicators increase together; on the other hand, a system with a low degree of synergy will be scattered, and for instance, one indicator may be too high while the others fail to rise.

2.3 Decomposition of Integration Value-Added Capacity Indicators in Response to the Transformation of Industrial Forms

The structure of the industry has changed as follows: it has moved from large-scale standardised production to flexible customised production, the chain of added value has been extended from manufacturing to services, and the model for managing the product life cycle is no longer linear but circular. The two parts of the index of integrated value-added capacity are educational value addition and industrial value addition. The former is an index of how much participation in joint activities increases students' technical literacy and problem-solving skills; the latter shows how much such joint activities can improve the efficiency and reduce the cost of the industry. The two dimensions are added to get the total value-added capacity of the integrated system, and without either of these dimensions, we would not know how large the integration value-added capacity actually is.

The decomposed indicators under the dimension of educational value addition are the scope of technical skill transfer, which refers to how extensive the technical changes in the neighbouring position are and how well a learner can adapt after training for that position, and the efficiency of abnormal situation handling, which is the learner's accuracy rate in autonomous decision-making and the time it takes to resolve non-standardised production anomalies. The decomposed indicators in the dimension of industrial value-added activities are: the contribution rate of process parameter optimisation, which is the proportion of process improvement proposals put forward by teachers and students of higher vocational colleges that are adopted by the industrial side and result in measurable efficiency gains; and the coefficient of implicit cost reduction, which is the reduction in recruitment and screening costs, loss during the adaptation period of new employees, and expenses for external technical consulting due to integration activities. The synthesis of the two types of indicators is nonlinear, and with the addition of educational value and industrial value addition, there may be an alternation in their leading positions. When the technology was still in its infancy, there were some applications in education; now that it has developed considerably, its main purpose is to support the development of heavy industry.

3. Weight Allocation and Synthesis Model of the Evaluation Indicator System for the Degree of Industry-Education Integration

3.1 Inter-dimensional Correlations of Integration Degree Indicators and the Weighting Strategy

The inter-dimensional correlation of the integration degree indicators is not zero, and there is also interaction among the three main dimensions: integration adaptability, integration synergy degree and integration value-added capacity. The adaptability index is the lag in technological response and the deviation of knowledge coverage; the synergy degree index is the direction of factor flow and the efficiency of transformation; and the value-added capacity index is the marginal contribution of the education side and the industry side. The three correlations are not the sum of the first two. Although it is more flexible, there will be a loss of short-term synergy, and with the rapid development of technology, the stable structure of the current resource sharing will be disturbed. Generally speaking, a high addition to value is in line with synchronicity, but high adaptability does not need to be correlated with a high addition to value. Given the above reasons, a correction mechanism will be added to the weighting strategy of the inter-dimensional interaction term to avoid the systematic bias caused by assuming independence in the weight allocation[5].

The weight method is a combination of the two mentioned above; that is, it is both subjective and objective. Subjectively, a group decision-making model of the Analytic Hierarchy Process is employed to have experts in the field of technical skill formation generate an initial weight vector by pairwise comparison of the relative importance of dimensions. A Judgment Matrix of Interaction Effects should be used to determine the synergy and conflict of the indices. Based on the combined measure of the coefficient of variation and information entropy at the objective level, the information load of each indicator is determined by pre-collected observational data on the degree of integration. The indices in the data that have a large spread are given a relatively high weight. Multiplicative Normalisation is used to obtain the final weight vector, and a weight adjustment parameter is added to moderate the proportion of contribution given to subjective judgment and data features. The two ways above can be used together to reduce the bias in the estimate of dimensions caused by interaction among them.

3.2 Calculation Method of the Composite Index Based on Integration Maturity Classification

The four stages of maturity in the integration classification of the industry-education system are: the loose-contact stage, the structural-cooperation stage, the system-embedding stage and the ecological-symbiosis stage. Each level is an instance of integration and the corresponding range of thresholds. The first is to set the base level before calculating the composite index. The calculation method is to determine the order of preference according to the degree of similarity to the ideal solution in a multi-attribute decision-making model and then correct it by combining graded anchor points. Set the ideal range and the upper limit of the critical value for all indicators first. The ideal value interval is taken from the observation distribution of higher vocational colleges of the same type that are at the system embedding level and above, and the critical value boundary is set according to the quantile breakpoints between the loose contact level and the structural collaboration level.

The two stages of index generation are as follows. The first step calculates the dimension-level scores. Map the observed values of all indicators to the range[0, 1] with membership functions. The form of the membership function is S, and it is non-linear in the range of low to high values for the indicators. Aggregation of indicators in a dimension is a weighted geometric mean, and it is assumed that all these indicators need to be achieved at the same time for the dimension to be realised. The second is to calculate the total integration index. A Nonlinear Combination Method is Used for the Three-Dimensional Scores. The model assumes that there is little compensability among the dimensions; that is to say, a low score in one dimension cannot be offset by a high score in another dimension. The Substitution Coefficient is determined by the Antagonistic parameters obtained from the inter-dimensional correlation analysis. The final index value is in the range[0,1], and it corresponds to the judgment rules for the four levels of integration maturity. Fuzzy intervals are added at the ends to avoid losing information due to rigid division.

3.3 Reliability and Validity Verification of the Evaluation Indicator System and the Dynamic Calibration Mechanism

The two kinds of reliability checks are internal consistency and measurement stability. Cronbach's alpha coefficient and hierarchical reliability coefficients will be used to determine whether the indicators have good internal consistency, and the homogeneity of the items in the whole set of indicators and in each dimension will be examined. If there are many interaction terms in the index system, we need to calculate the covariance reliability index among the dimensions to determine the consistency of the items in these dimensions. The two kinds of reliability tests are test-retest reliability and parallel-forms reliability. Calculate the correlation coefficient of the integration degree index for the same higher vocational college at two different times and set the interval to three to six months. At the same time, the two parallel sets of indicators are used for cross-validation as well. If the correlation coefficient is lower than the upper limit, it may be that the indicators have been defined ambiguously or the observation protocol needs to be revised.

The three kinds of validation are content, construct and criterion validity. For content validity, we will have independent experts in the fields of technical skill formation and educational measurement review the indicators to determine how well they align with the definitions of the dimensions, calculate the content validity index, and exclude indicator items that fall below the threshold. To verify the construct validity, confirmatory factor analysis is used to determine whether the proposed dimensional structure is reasonable, and then the differences in fit indices among the various models (one-dimensional model, two-dimensional model, etc.) are compared. If the goodness of fit for the three-dimensional model is much better than that of the other models, then construct validity has been established. For criterion validity, the technical adaptation cycle and the efficiency of solving technical problems in the industry of the graduates are taken as external criteria, and the correlation coefficient between the integration degree index and these criterion variables is calculated. The Dynamic Calibration Mechanism will change the parameters of the indicator system every two evaluation periods. At the bottom of the update is the indicator discrimination decay curve and the temporal drift detection of inter-dimensional correlations. If the discrimination index of an indicator is lower than the upper bound or if there is a structural change in the inter-dimensional correlation coefficients, then weight adjustment and critical value resetting will be carried out.

Conclusion

In light of the development plan for new quality productive forces, this paper presents a complete set of evaluation indicators for the degree of industry-education integration in higher vocational colleges, along with the theoretical basis, selection of indicators, weight assignment and synthesis model for this evaluation. Based on the above analysis, the level of industry-education collaboration can be divided into three types of strategic cooperation, resource sharing and performance feedback, and it is changing from loose coupling to structured integration. According to the three main directions of the speed of technological iteration—production factor reconstruction and industrial form transformation—indices for adaptability, degree of synergy and added-value capacity have been developed to move away from the old model of static cooperative activities and achieve measurement of dynamic matching quality and system value-added efficiency. The combined weighting method and the composite index synthesis method for classifying the integration maturity have solved the problems of non-orthogonality and limited compensability of the dimensions. In the future, to improve the reliability and validity of the evaluation system, we will continue to make revisions. In the future, the adaptability test for the indicator system will be extended to all kinds of higher vocational colleges and various circumstances; weights will be assigned to the different factors, longitudinal tracking data will be added to verify the predictive effect of the integration degree index on the medium- and long-term technical adaptability of graduates, and a closed-loop feedback mechanism will be established among the evaluation results, teaching diagnosis and resource allocation to promote the expansion of the evaluation tool from measurement and diagnosis to intervention and optimisation.

Fund Projects

Research on the Construction of the Evaluation Indicator System for the Industry-Education Integration Degree in Higher Vocational Colleges Based on the New Quality Productive Forces Development Strategy

Project No.: 2024XYXD-6

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