The Assessment of the Industry-Education Integration Degree in Higher Vocational Colleges under the Guidance of the New Quality Productive Forces Development Strategy

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Abstract: *The new quality productive forces are digitised, networked and intelligent, so we need to determine whether the system of industry and education has changed from a model of fixed resource supply to one based on dynamic capability development. The paper divides the multi-level structure of the integration degree and shows that the value logic of the evaluation has shifted towards the efficiency of capability generation. Construct an index for the width of the integration in terms of resource flow, develop an indicator system for the depth of integration based on capability adaptation, and add time-series indicators such as capability gap and response delay. A dynamic weight allocation model based on the technology readiness level has also been introduced, a measurement function and an estimation algorithm have been developed, a multi-source data calibration mechanism has been designed, and a reliability and validity test mechanism has been established. First, a reasonable plan for the quantity analysis of the scope of industry-education cooperation should be made.*

Keywords: *New Quality Productive Forces, Industry-Education Integration Degree, Integration Breadth, Integration Depth, Dynamic Weight Allocation, Evaluation Model*

Introduction

Organise the improvement of the talent training system for high-vocational colleges in accordance with the development plan of the new quality productive forces. As an important indicator of the level of cooperation between universities and enterprises, the form of assessment for industrial-educational integration now needs to be changed from the old model of resource sharing to that of technological symbiosis. At present, the assessment indicators for industry-education cooperation are relatively simple, and most of them are basic indicators that only show the quantity of joint projects and investment in facilities. However, there have been no changes in the circumstances or the whole-system response to new technologies today. The research value of this paper is to build an embedding mechanism for the factors of new quality productive forces in industrial-educational integration, discover the multi-level structural features and changes in the value logic of the integration degree, and move away from the old static weighted synthesis model. According to the flow and depth of resources, general Design indices and capability-adaptation-based depth indices have been developed, and a dynamic weight-allocation model has been established to consider the different stages of technology introduction, diffusion and maturity. A quantitative estimation model has been built, and all the assessments of measurement accuracy, calibration of parameters, reliability and validity have been conducted. The purpose of this paper is as follows: If an integration-degree evaluation tool that considers the technical characteristics of the New Quality Productive Forces is not specifically developed, there will be a structural mismatch between the construction capacity of colleges and the technological changes in industries, and thus effective support for talent cultivation in the operation system of the New Quality Productive Forces will not be achieved.

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

1.1 Embedding Mechanism of Factors of New Quality Productive Forces in Industry-Education Integration

The technical characteristics of the new quality productive forces are digitalisation, networking and intelligence, and the main reasons for this are the new types of production factors, such as algorithm-driven operation, data resources, intelligent equipment and green production processes. Given the above reasons, the demand for traditional vocational positions has changed, and thus, the talent training process in higher vocational colleges should integrate the technical parameters and operating logic of production workflows. The embedding mechanism is shown by the inward migration of technical standards into teaching standards; that is to say, equipment operation specifications, quality control protocols and maintenance procedures derived from the New Quality Productive Forces have been incorporated into the basic components of the curriculum content system. At the same time, with the change in the production organisation model from fixed assembly lines to flexible task teams, the teaching organisation in colleges also needs to add structural attributes such as modular course scheduling and cross-disciplinary skill combination to achieve node overlap between the production system and the teaching system at the operational level.

A second kind of embedding method is used to construct the factor flow channel, and it has both directions of data flow, process flow and talent flow. Anonymise the process optimisation data and equipment operation logs obtained from the operation of the New Quality Productive Forces, and then add them to the knowledge base of colleges as teaching case materials. The Remote Operation and Maintenance Interface of the intelligent equipment supplier can be employed to share fault diagnosis models and maintenance solutions from the college training platform with the corporate production system. With the rapid development of the skills of new workers, some colleges have started to add real-time updates on industry skills to their courses, such as digital work guidance systems and augmented reality-assisted operation modules. The multi-channel factor embedding shown above can help us break free from the old model of resource sharing in industry-education integration and build a symbiotic system based on technological isomorphism.

1.2 Multi-level Structural Characteristics of the Industry-Education Integration Degree

The index of the level of industry-education collaboration is not a single indicator but takes the form of three: strategic leadership stage, resource coordination stage and practical implementation stage. The first purpose of the Strategic Guidance Layer is to determine how well the layout of college specialisation groups aligns with the regional industrial technology roadmap, and this alignment will be reflected in the speed of response and mobility of specialisation construction. The purpose of the Resource Interaction Layer is to share and exchange the efficiency of factors such as equipment and facilities, faculty technical expertise and knowledge results, etc. At the time of implementation, we will ensure that the alignment accuracy of the course modules, training projects and evaluation norms meets the actual conditions at the production site. The three levels are in a hierarchy; if the direction of the strategy changes, there will be disorganisation in resource allocation at the level of resources, and a low coupling at the operational execution stage will reduce the feedback and correction ability of the strategic level[1].

Each level has its own sub-dimensions, and thus they are a nested series of attributes. The other two attributes of the strategic guidance layer are technology foresight distance and transformation resilience index; the former is the time lag between specialisation groups and the appearance of replacement industrial technology, and the latter shows how quickly a specialisation can change its direction package. The attributes of the resource interaction layer are the equipment sharing coefficient, the two-way appointment rate for technical teachers, and the industrialisation cycle of joint industry-university research and development results. The attributes of the operation and execution layer are close to process hours, have a uniform quality inspection norm, and cover all kinds of procedures for dealing with abnormal operation conditions in teaching. For the reasons mentioned above, the assessment of the degree of industry-education integration cannot be carried out through a single weighted sum; instead, one should determine the transmission paths and non-linear coupling effects among all the levels.

1.3 The Value Logic Shift in the Evaluation of Integration Degree

Generally speaking, the traditional indicators of industry-education integration are external and easy to measure, such as the amount of investment, the number of joint projects or the duration of student internships; their underlying value system is usually that of an engineering mind focused on input-output efficiency. In light of the new strategy for the development of high-quality productive forces, the value logic of assessment has changed from "how many resources are used" to "how efficiently capabilities are created". Capability generation refers to the ability of the human resources produced by colleges to directly enhance the technical efficiency of the key links in the operational system of the new quality productive forces. At this time, the purpose of the evaluation is to determine how well people have been trained to use the new technology in their work. Therefore, the criterion for determining whether a graduate is excellent or average has been raised to whether they have shown the behaviour of diagnosing anomalies, reconfiguring parameters, or putting forward local optimisation ideas in an intelligent production environment.

At the same time, as the values have changed, so too has the foundation for evaluation moved from fixed professional qualifications to the dynamic development path of technology. The technological half-life of the new quality productive forces has been shortened, and the demand for vocational skills is constantly changing. Therefore, the degree of integration will determine whether a synchronous iteration feedback loop has been formed among colleges and enterprises. That is to say, consider how far back the update frequency of teaching content is from changes in industrial technology, and also assess the generation gap between the technological level of training equipment and the actual equipment on the production line. An even deeper change is that the level of integration should no longer be regarded as a necessary condition for good results; rather, it should be seen as an indicator of the system's responsiveness, that is, how quickly the college teaching system can respond to changes in technology and adjust its integration model. Therefore, the new logic of values should be judged by its process and not by the old structure-oriented mode.

2. Indicator Extraction and System Architecture for the Evaluation of the Degree of Industry-Education Integration

2.1 Design of Integration Breadth Indicators Based on Resource Flow

The range and frequency of links for factor exchange among higher vocational colleges and enterprises are called integration breadth. The three kinds of forms in which the flow of resources can be divided are material resources, human resources and information resources. The index of the flow of material resources is the frequency of equipment asset sharing, the supply-chain matching coefficient for training consumables and the cross-organizational turnover rate of technical samples. The two indicators in the index for the flow of human resources are the two-way retention period of technical specialists, the rotation coverage rate of internship positions and the density of task interaction between technical mentors and course instructors. The indices of the flow of information resources are: the anonymised sharing rate of production process documents, the proportion of equipment maintenance logs that have been turned into teaching cases, and the frequency of organising unit joint technical seminars. The above indices are in fact indicators of the extent of integration at the level of industry-education cooperation.

The Scope of the Integration Requirement should be determined according to the Directionality and Intensity of the Flow. Directionality refers to the direction of the flow of resources from the industrial side to the college side, from the college side to the industrial side, or whether there is a two-way balanced flow; different directions will have different integration effects. Flow intensity is defined as the ratio of the volume of flow per unit time to the channel capacity; for example, one can calculate it by dividing the total number of times a particular type of equipment is called in the reuse cycle between the college training room and the enterprise production line by the maximum schedulable number. To avoid double counting, network analysis can be used to find all the paths of resource flow and combine the duplicate counts into a single count along the path with the highest contribution. The Design of the integration breadth index should also exclude sporadic flows caused by short-term project cooperation, and non-stationary noise can be removed by setting the observation window length and the minimum flow threshold[2].

2.2 Indicator System of Integration Depth Based on Capability Adaptation

Depth of integration refers to the extent to which the ability structure of the talent cultivation output from higher vocational colleges is in line with the operating positions of the new quality productive forces. In terms of the type of ability, the Design of indicators should be changed from a list of basic skills in the job description to deep ability modules in the three areas of technical operation domain, fault diagnosis domain and process optimisation domain. Indicators of the technical operation domain are used to quantify how well students have learned the control command set for intelligent equipment, the rules for process parameter setting and quality detection algorithms, etc., by calculating the edit distance between the operation trajectory obtained from the simulation test platform and the standard template. The indices of the fault diagnosis domain are the recognition rate of an abnormal condition, the matching degree of a fault tree, and the rationality score of the maintenance plan generation; these are compared with the reference solution of the expert system based on the problem-solving path recorded by the digital assessment terminal.

Next in the list to be added to the combined depth indicator system is a time-series gap graph. The capability gap is the difference between the median actual capability of college graduates and the top percentile of capability of employees in the industry. The index shows the current level of adaptation and can also predict the direction of integration decay in the next three rounds of technological development. Considering that there is also a problem of time variation in capability adaptation, a response delay indicator needs to be added; that is to say, one should specify the update delay for the relevant capability units in the college teaching system after the industrial side releases new process procedures or equipment operation specifications. According to the statistics of the distribution of delays in all specialisation groups and various technical fields, the evaluator can obtain a profile of the unevenness of integration depth in the technical space and identify weak links in capability adaptation and areas for improvement.

2.3 Dynamic Weight Allocation Mode of the Evaluation System

Static weight allocation cannot show how the structure of the degree of industry-education integration has changed over time with the development of technology, so a mode of dynamic weight allocation needs to be added. The three periods of the evaluation cycle are the technology introduction stage, the diffusion stage and the maturity stage, and they each have different weight coefficients for the first-level indicators in line with the characteristics of the technology for New Quality Productive Forces. With the development of new technologies, the weight of capability units for fault diagnosis and process optimisation in the integration depth indicator has been rising, and since these new technologies are still in their infancy, they need to be applied flexibly rather than standardisedly. Increase the weight of the information resource flow in the diffusion period for the integration breadth index; that is to say, after technological standardisation, the efficiency of knowledge transfer has become the bottleneck for integration. At the stage of maturity, the weights of the three types of indicators are relatively equal, but a technology lock-in risk correction factor should be added to reduce the weight of an integration mode that is too dependent on a single technological path.

Another way to change the weights is to have a self-tuning algorithm with feedback. At different times during the evaluation period, the evaluator gathers the measured values of the indicators, uses principal component analysis to obtain the path of change for the contribution rate of each indicator to the total variance of the integration degree, and then updates the weight matrix for the next cycle accordingly. To avoid the problem of uneven distribution in the evaluation caused by a large change in weight, a smoothing coefficient should be employed, and the maximum adjustment range per cycle needs to be set. At the same time, a Bayesian prior distribution is also employed for the prior weights of the experts, and after each evaluation, the true weight structure is updated to form a posterior distribution. With the development of industrial technology, the weights of the items in the assessment will be adjusted automatically to maintain the same level of the assessment results.

3. Model Construction and Validation Path for the Quantitative Evaluation of the Industry-Education Integration Degree

3.1 Measurement Function and Estimation Algorithm for the Integration Degree

The measurement function of the integration degree should map the above breadth indicators and depth indicators to a common measurement space. The two independent variables in the combined function of the evaluator are the density of resource flow and the tightness of capability adaptation; the density of resource flow refers to the cross-organizational exchange rate of the three types of resources (material, human and information), and the tightness of capability adaptation is the similarity of capability profiles at the skill output end and the industrial technology operation end. The function of aggregation is not directly related to the extent of aggregation; that is, at a low level of integration, breadth and depth are highly substitutable, but at a high level of integration, they are complementary and mutually reinforcing. The first way to find the effective range of the degree of integration in the estimation algorithm is boundary search, and then hierarchically embedded operators are used to combine the indicator scores of the strategic guidance layer, the resource interaction layer and the operational execution layer at different levels according to their transmission paths, avoiding dimensional compression distortion caused by direct weighting.

Given that the technological iteration of the New Quality Productive Forces is non-stationary, a time-decay factor is added to the measurement algorithm to account for the different contributions of integration behaviour at various times to the current level of integration. The closer an industry-education collaboration event is to the evaluation period, the higher the information entropy will be at that time, and thus the greater the weight given by the evaluator. The Measurement Algorithm will set the truncation threshold for the technology lag period and exclude any historical integration activities outside of this threshold from the measurement period. Design can automatically solve the old problem of technological dependence in the evaluation of integration. The form of the algorithm implementation for the evaluator is a hierarchical nested integral; each specialisation group is considered an independently integrated unit for separate measurement, and then a secondary aggregation is carried out based on its correlation strength with the regional technological spectrum of New Quality Productive Forces to obtain the overall integration degree value of the college[3].

3.2 Evaluation Parameter Calibration in Multi-source Data Fusion

There are many reasons for the heterogeneity of the data in the calibration problem for evaluation parameters, such as equipment operation records, teaching management system data, simulation assessment terminal output, technical communication documents, etc. The first problem that multi-source data fusion needs to solve is the issue of dimension alignment; that is, the original observations of different magnitudes, such as the utilisation rate of training equipment, the frequency of course updates and the fault diagnosis score, must be converted into a common standard score scale. Robust statistics are used in the calibration to identify and ignore outliers caused by abnormal operation of the data-acquisition terminal or changes in recording format, so one abnormal observation will not significantly affect the estimation of parameters. At the intersection nodes of multimodal data, redundancy check rules are set; for example, the number of equipment calls should be cross-referenced with the corresponding course scheduling records of the teaching class, and if there is a discrepancy in the data, the value with the lower confidence level will be taken as the calibration input to avoid the accumulation of positive bias.

The second aim of parameter calibration is to discover and correct for the measurement variations in the errors of the indicator system. Since the frequency of flow for the information resource in the integration breadth indicator cannot be obtained directly, proxy variables such as the traffic of file transfer protocols and download logs of enterprise cases in the teaching system need to be used for indirect measurement, and these measurement processes introduce non-systematic errors. According to the method of parallel measurement, several proxy indicators for the same factor are used to estimate the error variance of a calibration algorithm, and then the true signal component is separated from the original data. For new integration behaviours that have arisen due to the technological development of the New Quality Productive Forces, such as the teaching invocation of remote operation and maintenance interfaces, since there are no historical calibration reference points, bootstrap resampling is used to generate multiple sets of mimic datasets, the uncertainty interval of the parameters for this type of indicator is determined through repeated iterations, and then this interval is taken as the error bound for the next calculation of the degree of integration.

3.3 Reliability and Validity Test Method for the Evaluation Results

Reliability testing will be carried out to determine the consistency of the integration-degree measurement results obtained by all raters at different times and in different groups of parallel indicators. The evaluator will use the test-retest reliability method, and after one cycle of technology iteration (which generally corresponds to the average time for updating the core technology parameters of the New Quality Productive Forces), they will repeat the assessment of the degree of integration at the same higher vocational college and calculate the rank correlation coefficient between the two sets of results. If the correlation coefficient is lower than the upper limit, it means that the measurement function of the integration degree is too sensitive to technological changes, and therefore the evaluator needs to adjust the time decay factor or the truncation threshold. At the same time, the evaluator will also carry out a split-half reliability test; randomly divide the indicator set for integration breadth into two parts, calculate the scores of these two parts separately, and then conduct a correlation analysis to ensure that the internal consistency structure of the indicators is stable and to avoid falsely high reliability due to the dominance of a single indicator.

The purpose of verification is to confirm that the results of the assessment meet the necessary conditions for the development of high-quality productive forces in China through the integration of industry and education. Content validity refers to whether the indicators cover all the contents as reviewed by experts; it has been confirmed that the main integration nodes of the intelligent production system, such as measurement items for algorithm maintenance capability and data governance capability, have not been omitted. Discriminant validity will be used to establish construct validity, and then partial correlation analysis will be conducted on the results of the integration degree assessment and traditional indicators such as the internship job-matching rate and the number of cooperative enterprises. If the degree of integration is relatively low compared with that of the traditional indicators, it can be concluded that the evaluation framework is assessing different constructs and has independent construct validity. Criterion validity is taken to be the technical adaptation cycle of higher vocational college graduates after taking up jobs related to the new quality productive forces as an external criterion, and the strength of the negative correlation between the integration degree score and the length of this adaptation cycle is calculated. The shorter the adaptation cycle, the more accurate the prediction will be of the integration-degree evaluation results for the external criterion; thus, we can verify the real-world reference validity of the evaluation model.

Conclusion

Systematic studies have been carried out on the theoretical deconstruction and index extraction of the degree of industry-education integration in higher vocational colleges under the new quality productive forces development strategy, and a quantitative model has been constructed. Research has shown that the three stages of integration are the strategic leadership stage, the resource cooperation period and the operation implementation stage; now, the focus is on how well dynamic capabilities have been built rather than on the utilisation efficiency of static resources. According to the flow of resources, three-dimensional breadth indicators for material, human and information resources have been developed at the level of indicators; in terms of capability adaptation, three areas of technical operation, fault diagnosis and process optimisation have been set up at the level of depth, and time-series measurement parameters such as capability gap and response delay have been added. The evaluation system put forward in this paper is to give different weights to the attributes according to the stage of technology maturity, develop a non-linear measurement function, build a hierarchical nested estimation algorithm, add a robust parameter calibration method for multi-source data fusion, and establish a testing mechanism that includes test-retest reliability, split-half reliability, content validity, construct validity and criterion validity. In the future, the following additions will be made: A feedback loop mechanism will be introduced to adjust the specialisation group according to the evaluation results of the degree; Specialised indicator sets for intelligent manufacturing, digital twins and green processes will be developed; Longitudinal follow-up data will be added to verify the reliability of the prediction ability of the technical adaptation cycle for graduates; and automatic data collection and real-time update structures will be established for the evaluation system.

Fund Projects

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