The assessment of the industry-education integration degree in higher vocational colleges under the guidance of the New Quality Productive Forces Development Strategy

Yikun Wang*

LAN ZHOU VOCATIONAL TECHNICAL COLLEGE, lanzhou, 730070, China
**Corresponding author: monicawang1734@163.com*

Abstract: *The New Quality Productive Forces feature digitalization, networking, and intelligence as their technical characteristics, and the embedding of their elements requires the evaluation of industry-education integration to shift from static resource input to a logic of dynamic capability generation. This paper deconstructs the multi-level structure of the integration degree, and clarifies that the value logic of the evaluation shifts toward the efficiency of capability generation. It designs indicators of integration breadth from the perspective of resource flow, constructs an indicator system of integration depth from the perspective of capability adaptation, and introduces time-series indicators such as capability gap and response delay. Furthermore, this paper proposes a dynamic weight allocation model based on technology readiness levels, constructs a measurement function and an estimation algorithm, and designs a multi-source data calibration mechanism as well as a reliability and validity testing mechanism. This paper provides a systematic analytical framework for the quantitative assessment of the industry-education integration degree.*

Keywords: *New Quality Productive Forces; industry-education integration degree; integration breadth; integration depth; dynamic weight allocation; evaluation model*

Introduction

The New Quality Productive Forces development strategy imposes a systematic restructuring requirement on the talent cultivation model of higher vocational colleges. As a core construct for measuring the depth of collaboration between colleges and industrial entities, the industry-education integration degree urgently needs to shift its evaluation framework from the traditional logic of resource exchange to the logic of technological symbiosis. Current evaluation methods for industry-education integration mostly focus on explicit indicators such as the number of cooperative projects and the scale of equipment investment, and they struggle to capture the dynamic characteristics and systemic responsiveness of capability generation in the context of accelerating technological iteration. The research significance of this paper is as follows: it defines the embedding mechanism of New Quality Productive Forces factors into industry-education integration, reveals the multi-level structural characteristics and the value logic shift of the integration degree, and breaks through the static weighted synthesis paradigm. It designs breadth indicators based on resource flow and depth indicators based on capability adaptation, and constructs a dynamic weight allocation model that accommodates the stage-specific differences of technology introduction, diffusion, and maturity. Furthermore, it develops a quantitative evaluation model that includes a measurement function, parameter calibration, and reliability and validity testing. The necessity of this study is reflected in the following: the lack of an integration degree evaluation tool tailored to the technical features of the New Quality Productive Forces will lead to a structural mismatch between the capability building of colleges and the technological evolution of industries, thereby restricting the effective support of talent cultivation for the operational system of the New Quality Productive Forces.

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

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

The New Quality Productive Forces feature digitalization, networking, and intelligence as their technical characteristics, and their core factors include new types of production inputs such as algorithm-driven operations, data resources, intelligent equipment, and green production processes. These factors alter the capability requirements of traditional vocational positions, thus forcing the talent cultivation process in higher vocational colleges to absorb the technical parameters and operational logic from production workflows. The embedding mechanism manifests as the inward migration of technical standards into teaching standards, meaning that the equipment operation specifications, quality control protocols, and maintenance procedures derived from the New Quality Productive Forces are transformed into the basic components of the curriculum content system. Meanwhile, the transformation of the production organization mode from rigid assembly lines to flexible task teams requires the teaching organization in colleges to introduce structural features such as modular course scheduling and cross-disciplinary skill combinations, thereby achieving an overlap of nodes between the production system and the teaching system at the operational level.

Another type of embedding mechanism is reflected in the establishment of factor flow channels, including the two-way integration of data flows, process flows, and talent flows. The process improvement data and equipment operation logs generated during the operation of the New Quality Productive Forces, after being anonymized, can be reversely fed into the knowledge base of colleges as teaching case resources. The remote operation and maintenance interfaces provided by intelligent equipment suppliers allow the training platforms of colleges to share fault diagnosis models and maintenance solutions with corporate production systems. Furthermore, the accelerated iteration speed of skilled workers' capabilities prompts colleges to directly embed the real-time skill update mechanisms within enterprises—such as digital work guidance systems and augmented reality-assisted operation modules—into the teaching process. This multi-channel factor embedding enables the industry-education integration to no longer remain at the level of resource exchange, but to form a symbiosis based on technological isomorphism.

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

The industry-education integration degree is not a linear measure of a single dimension but rather a structural attribute comprising three levels: the strategic guidance layer, the resource interaction layer, and the operational execution layer. The strategic guidance layer mainly involves the degree of alignment between the layout of college specialty groups and the regional industrial technology roadmap, which is manifested in the response speed and migration elasticity of specialty setup. The resource interaction layer covers the sharing density and two-way transformation efficiency of factors such as equipment and facilities, faculty technical expertise, and knowledge outcomes. The operational execution layer focuses on the alignment accuracy between course units, training projects, and evaluation standards and the actual procedures of the production site. A clear recursive relationship exists among the three levels: strategic guidance deviations can lead to disorder in resource allocation, while low coupling at the operational execution layer can inversely suppress the feedback and adjustment capability of the strategic layer[1].

Each level further contains different sub-dimensions, thus forming a nested spectrum of characteristics. The characteristics of the strategic guidance layer can be further extracted as the technology foresight distance—that is, the time lag between the specialty groups and the industrial technology generation replacement—as well as the transformation resilience index, which measures the ability of a specialty to quickly reorganize its course packages. The characteristics of the resource interaction layer include the equipment sharing coefficient, the two-way appointment rate of technical teachers, and the industrialization cycle of joint industry-university research and development outcomes. The characteristics of the operational execution layer focus on the process-hour matching degree, the consistency of quality inspection standards, and the coverage rate of abnormal operating condition handling procedures in teaching. This multi-level structure determines that the evaluation of the industry-education integration degree cannot adopt a simple weighted synthesis, but rather needs to identify the transmission paths and non-linear coupling effects among the levels.

1.3 The Value Logic Shift in the Evaluation of the Integration Degree

Traditional evaluations of industry-education integration usually focus on explicit and measurable indicators such as resource input volume, the number of cooperative projects, or student internship person-times, and their implicit value logic is an engineering mindset based on input-output efficiency. Under the guidance of the New Quality Productive Forces development strategy, the value logic of the evaluation shifts from "how many resources are occupied" to "the efficiency of capability generation." Capability generation refers to the ability of the human capital output by colleges to directly drive the technical effectiveness of key nodes in the operational system of the New Quality Productive Forces. The core concern of the evaluation is no longer passive job matching but active technical adaptation and process improvement capability. This means that the criterion for judging a high or low integration degree becomes whether graduates possess the behavioral characteristics of diagnosing anomalies, reconfiguring parameters, or proposing local optimization solutions in an intelligent production environment.

This value logic shift simultaneously triggers a change in the evaluation reference framework, moving from static occupational qualification standards to dynamic technological evolution trajectories. The technological half-life of the New Quality Productive Forces is significantly shortened, and vocational capability requirements are in a state of continuous restructuring. Therefore, the integration degree must assess whether a synchronous iteration feedback loop has been established between colleges and industries. Specifically, the evaluation should examine the time lag between the update frequency of teaching content and the notification of industrial technology changes, as well as the generation gap between the technological generation of training equipment and the active equipment on production lines. A deeper shift lies in the fact that the integration degree no longer characterizes a description of a result state but rather a measure of systemic responsiveness—that is, the ability of the college teaching system to respond to technological disturbances and quickly reorganize the integration model. This value logic shift requires the evaluation framework to move from a structure-oriented approach to a process-oriented approach.

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

2.1 Design of Integration Breadth Indicators Based on Resource Flow

Integration breadth reflects the coverage range and connectivity density of factor exchange between higher vocational colleges and industrial entities. From the perspective of resource flow, the integration breadth indicators should be extracted from three flow dimensions: material resources, human resources, and information resources. The material resource flow indicators include the sharing frequency of equipment assets, the supply chain matching coefficient of training consumables, and the cross-organizational turnover rate of technical samples. The human resource flow indicators focus on the two-way retention duration of technical specialists, the rotation coverage rate of internship positions, and the task interaction density between technical mentors and course instructors. The information resource flow indicators cover the anonymized sharing rate of production process documents, the proportion of equipment maintenance logs transformed into teaching cases, and the unit frequency of joint technical seminar activities. These indicators collectively constitute the measurement vector of integration breadth, characterizing the spatial extension degree of industry-education integration.

The quantification of integration breadth requires the consideration of two parameters: flow directionality and flow intensity. Directionality refers to the flow of resources from the industrial side to the college side, from the college side to the industrial side, or a two-way balanced flow, and different directions correspond to different integration effects. Flow intensity is calibrated by the ratio of the flow volume per unit time to the channel capacity; for example, it is calculated as the total number of times a certain equipment type is called within the reuse cycle between the college training room and the enterprise production line divided by the maximum schedulable number. To avoid double counting, the evaluator should use the network analysis method to identify multiple paths of resource flow and merge duplicate counts into the single path with the highest contribution. The design of integration breadth indicators should also exclude sporadic flows caused by short-term project cooperation, and it should filter out non-stationary noise by setting the observation window length and the minimum flow threshold[2].

2.2 Indicator System of Integration Depth Based on Capability Adaptation

The integration depth refers to the matching tightness of the capability structure between the talent cultivation output of higher vocational colleges and the operational positions of the New Quality Productive Forces. The capability adaptation perspective requires the indicator design to shift from the surface-level skill list in job descriptions to the deep capability units, including three dimensions: the technical operation domain, the fault diagnosis domain, and the process optimization domain. The technical operation domain indicators measure the students' mastery accuracy of the intelligent equipment control command sets, process parameter setting rules, and quality detection algorithms, and they quantify this accuracy through the edit distance between the operation trajectory extracted from the simulation test platform and the standard template. The fault diagnosis domain indicators focus on the abnormal condition recognition rate, the fault tree matching degree, and the rationality score of maintenance plan generation, and they use the problem-solving path recorded by the digital assessment terminal to compare with the reference solution of the expert system.

The innovation of the integration depth indicator system lies in the introduction of time-series indicators of capability gap. The capability gap refers to the distance between the median actual capability of college graduates and the top percentile of capability of on-the-job personnel on the industrial side. This indicator not only reflects the current adaptation level but can also predict the trend of integration decay over the next three technology generation cycles. Furthermore, the time-varying characteristic of capability adaptation requires the design of a response delay indicator, that is, the update delay of the corresponding capability units in the college teaching system after the industrial side issues new process procedures or equipment operation specifications. Through a statistical analysis of the delay distribution across different specialty groups and different technical fields, the evaluator can obtain a profile of the unevenness of integration depth in the technical space, and then identify the weak nodes of capability adaptation and the areas to be strengthened.

2.3 Dynamic Weight Allocation Mode of the Evaluation System

Static weight allocation struggles to capture the structural changes of the industry-education integration degree across different technological evolution stages; therefore, it is necessary to construct a dynamic weight allocation mode. This mode is based on the stage characteristics of the technology maturity of the New Quality Productive Forces, and it divides the evaluation cycle into the technology introduction period, the diffusion period, and the maturity period, with each period assigning differentiated weight coefficients to different first-level indicators. During the technology introduction period, the weight of capability units involving fault diagnosis and process optimization in the integration depth indicator is increased, because the incompleteness of new technologies requires flexible adaptation rather than standardized operations. During the diffusion period, the weight of information resource flow in the integration breadth indicator is increased, reflecting the fact that after technological standardization, the efficiency of knowledge transfer becomes the bottleneck of integration. During the maturity period, the weights of the three types of indicators tend to be balanced, but it is necessary to introduce a technology lock-in risk correction factor to reduce the weight value of the integration mode that overly relies on a single technological trajectory.

Another mechanism of the dynamic weight allocation is the weight self-adjustment algorithm based on feedback learning. The evaluator collects the measured values of indicators across multiple consecutive evaluation cycles, uses principal component analysis to extract the change trajectory of 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 incomparability of evaluations caused by drastic weight fluctuations, the evaluator should set a smoothing coefficient and specify a maximum adjustment range for a single cycle. At the same time, the evaluator introduces expert prior weights as a Bayesian prior distribution, and gradually approximates the true weight structure through posterior updates after each evaluation. This dynamic weight allocation mode enables the evaluation system to possess response sensitivity to industrial technology changes while maintaining a basis for longitudinal comparability with previous evaluation 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 needs to map the aforementioned breadth indicators and depth indicators into a unified measurement space. The evaluator constructs a composite function with the density of resource flow and the tightness of capability adaptation as two independent variables, in which the density of resource flow characterizes the cross-organizational exchange rate of the three types of resources (material, human, and information), and the tightness of capability adaptation characterizes the similarity of capability profiles between the skill output side and the industrial technology operation side. This function adopts a nonlinear aggregation strategy because the substitutability between breadth and depth is strong when the integration degree is at a low level, whereas the two exhibit a complementary and reinforcing relationship at a high level. The core of the estimation algorithm lies in determining the effective value range of the integration degree through boundary search, and in using hierarchical embedding operators to merge the indicator scores of the strategic guidance layer, the resource interaction layer, and the operational execution layer level by level according to the transmission paths, thereby avoiding the dimensional compression distortion caused by direct weighting.

In response to the non-stationary characteristics of technological iteration of the New Quality Productive Forces, the measurement algorithm introduces a time decay factor to distinguish the contribution differences of integration behaviors generated in different periods to the current integration degree. The closer the industry-education interaction event is to the evaluation time point, the higher the information entropy it retains, and the evaluator assigns a higher time weight accordingly. The measurement algorithm also sets a technological lag period truncation threshold, and the algorithm no longer includes historical integration activities exceeding the threshold in the measurement interval. This design enables the integration degree evaluation to automatically strip off obsolete technological dependency paths. At the algorithmic implementation level, the evaluator adopts a hierarchical nested integral form, treats each specialty group as a relatively independent integration unit for separate measurement, and then performs a secondary aggregation based on the strength of its correlation with the regional technological spectrum of the New Quality Productive Forces, finally outputting the overall integration degree value of the college[3].

3.2 Evaluation Parameter Calibration Under Multi-Source Data Fusion

The data heterogeneity faced by evaluation parameter calibration originates from different sources such as equipment operation logs, teaching management system records, simulation assessment terminal outputs, and technical communication documents. Multi-source data fusion first needs to solve the dimension alignment problem, which requires converting the original observations of different magnitudes, such as the utilization rate of training equipment, the course update frequency, and the fault diagnosis score, to a unified standard score scale. The calibration process adopts robust statistical methods to identify and eliminate outliers caused by abnormal data acquisition terminals or changes in recording formats, thereby avoiding excessive disturbance of a single abnormal observation to parameter estimation. At the intersection nodes of multimodal data, the evaluator sets redundancy check rules—for example, the number of equipment calls needs to be cross-validated with the corresponding course scheduling records of the teaching class, and when the data are inconsistent, the evaluator takes the value with the lower confidence level as the calibration input to suppress the accumulation of positive bias.

Another task of parameter calibration is to estimate and compensate for the measurement variance of the measurement errors existing in the indicator system. Because the frequency of information resource flow in the integration breadth indicators is difficult to observe directly, the evaluator needs to measure it indirectly through proxy variables such as the traffic of file transfer protocols and the download logs of enterprise cases in the teaching system, and such measurement processes introduce non-systematic errors. The calibration algorithm estimates the error variance by using multiple proxy indicators under the same construct based on the principle of parallel measurement, and then separates the true signal component from the original observations. For the brand-new integration behaviors emerging during the technological evolution of the New Quality Productive Forces—such as the teaching invocation of remote operation and maintenance interfaces—due to the lack of historical calibration reference points, the evaluator adopts the bootstrap resampling method to generate multiple sets of mimic datasets, calculates the uncertainty interval of the parameters of this type of indicator through multiple iterations, and uses that interval as the error boundary for the subsequent integration degree calculation.

3.3 Reliability and Validity Testing Mechanism for the Evaluation Results

The reliability test is used to assess the degree of consistency of the integration degree measurement results across different raters, different time slices, or different parallel indicator groups. The evaluator adopts the test-retest reliability method, and after an interval of one technology iteration cycle (which generally corresponds to the average duration of core technology parameter updates of the New Quality Productive Forces), the evaluator performs the integration degree evaluation on the same higher vocational college again, and calculates the rank correlation coefficient between the two evaluation results. If the correlation coefficient falls below a set threshold, it indicates that the measurement function of the integration degree is overly sensitive to technological changes, and the evaluator needs to adjust the time decay factor or the truncation threshold. At the same time, the evaluator adopts the split-half reliability test, randomly splits the indicator set of integration breadth into two subsets, calculates their scores separately, and then performs a correlation analysis to verify whether the internal consistency structure of the indicators is stable, thereby avoiding falsely high reliability caused by the dominance of a single indicator.

Validity testing focuses on whether the evaluation results truly capture the essential characteristics of the industry-education integration required by the development of the New Quality Productive Forces. Content validity verifies the completeness of the indicator set through the expert review method, and it confirms whether key integration nodes in the intelligent production system—such as measurement items for algorithm maintenance capability and data governance capability—have been omitted. Construct validity adopts discriminant validity testing, which conducts a partial correlation analysis between the integration degree evaluation results and traditional indicators such as the internship job-matching rate and the number of cooperative enterprises. If the integration degree shows a moderately low correlation with these traditional indicators, it proves that the evaluation framework measures different constructs and possesses independent construct validity. Criterion validity uses the technical adaptation cycle of higher vocational college graduates after they enter positions related to the New Quality Productive Forces as an external criterion, and it calculates the negative correlation strength between the integration degree score and the length of this adaptation cycle. The shorter the adaptation cycle, the stronger the predictive power of the integration degree evaluation results on the external criterion, thereby verifying the real-world reference validity of the evaluation model.

Conclusion

This paper completes a systematic study from theoretical deconstruction and indicator extraction to quantitative model construction for the evaluation of the industry-education integration degree in higher vocational colleges under the guidance of the New Quality Productive Forces development strategy. The study clarifies that the integration degree contains a multi-level structure consisting of the strategic guidance layer, the resource interaction layer, and the operational execution layer, and it elucidates the shift in the evaluation value logic from static resource occupation to dynamic capability generation efficiency. At the indicator level, this paper designs three-dimensional breadth indicators of material, human, and information resources based on resource flow, as well as three-domain depth indicators of technical operation, fault diagnosis, and process optimization based on capability adaptation, and it introduces time-series measurement parameters such as capability gap and response delay. At the evaluation system level, this paper constructs a dynamic weight allocation mode based on the stage characteristics of technology maturity, designs a nonlinear measurement function and a hierarchical nested estimation algorithm, proposes a robust parameter calibration method under multi-source data fusion, and establishes a testing mechanism covering test-retest reliability, split-half reliability, content validity, construct validity, and criterion validity. Future research directions include: the feedback linkage mechanism between the integration degree evaluation results and the dynamic adjustment of specialty groups, the development of specialized indicator subsets for fields such as intelligent manufacturing, digital twins, and green processes, the introduction of longitudinal follow-up data to validate the predictive power for the technical adaptation cycle of graduates, and the exploration of automated data collection and real-time update architectures for the evaluation system.

Fund Projects

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