

Exploring Practical Education Reform in Vocational Colleges under Industry-Education Integration: A Model of Tripartite-Chain Synergy and Four-Dimensional Advancement

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ABSTRACT Vocational education reform in China indicates that sustained policy efforts have reshaped the integration of industry and education, yet practical education in vocational colleges still faces a structural challenge: the industrial chain, education chain, and talent chain often operate in isolation. This study addresses this problem using interior design and environmental art design programs as the research context. A mixed-methods design is adopted to collect systematic data from faculty, students, and partner enterprises across six higher vocational institutions in South China, East China, and Southwest China. Based on the evidence, the study constructs and empirically tests a practical education reform model centered on four parallel dimensions: curriculum, practical training, faculty development, and quality evaluation. These dimensions are coordinated through a three-chain synergy perspective. The results show that the integration of three-chain synergy as an external ecosystem with a four-dimensional parallel mechanism as the internal operating structure provides a robust framework for practical education reform. The model clarifies how industry demand, curriculum content, training projects, teacher capability, and quality evaluation should be linked to improve the authenticity of practice and the workplace readiness of graduates. The findings offer a theoretical basis and empirical reference for systematic reform in comparable vocational institutions.

INDEX TERMS industry-education integration, three-chain synergy, practical education, quality evaluation, vocational colleges

I. INTRODUCTION

VOCATIONAL education in China shows that strategic transformation has become both unavoidable and urgent. Moreover, the significant findings from recent policy shifts indicate that quality development now functions as a central national priority. Furthermore, industry-education integration appears to have emerged as the key concern driving practical education reform across vocational colleges. Given that economic restructuring and accelerating industrial upgrading have intensified demand for technically skilled graduates, traditional talent cultivation models might indicate a systemic inability to meet that demand. Education reform shows policy gaps persist. However, the significant evidence from policy documents — such as the Opinions on Deepening Industry-Education Integration and the revised Vocational Education Law — shows that a clear institutional direction has been established at the top-level design stage. Additionally, the results demonstrate that these documents provide both policy justification and structural support for

rebuilding practical education systems. Furthermore, the results show that an imbalance between talent chain outputs and industry absorption capacity reflects a coordinated, system-level response that the evidence appears to demand. Given that these are not isolated issues, the findings indicate that they reveal a systemic misalignment calling for restructured educational resource allocation. Evidence shows issues are systemic. However, Yang argued that industry-education integration is the core logic enabling vocational talent supply, and that its effectiveness depends on restructuring educational resource allocation around industry needs [1]. Additionally, the significant findings from Li and colleagues demonstrate that dual-drive mechanisms — new infrastructure empowerment combined with industry-education integration — might indicate important forces for improving curriculum quality in higher vocational institutions [2]. In light of these perspectives, the key results show that a pressing question remains: how can the industrial chain, the education chain, and the talent chain

be brought into genuine synergistic coordination within the context of industry-education integration? Notwithstanding the existing scholarship, the evidence indicates that considerable theoretical discussion on industry-education integration has produced important but incomplete results. Gaps show coordination understudied. Most studies show that research concentrates on isolated dimensions — curriculum ideology, program development, or instructional reform — examined separately rather than as a unified system. Moreover, the evidence indicates that research addressing the coordinated advancement of all four core dimensions (curriculum, practical training, faculty development, and quality evaluation) appears comparatively scarce. Given that the findings demonstrate that application-oriented universities benefit from integrated approaches, Teng and colleagues found that combining science-education integration with industry-education integration could activate the intrinsic drivers of talent cultivation [3]. Furthermore, the significant results show that their work gives limited attention to four-dimensional coordination mechanisms specific to vocational colleges. Study shows three-chain synergy underexplored in vocational context. However, Wang Zhaokuan's study of a "three-chain" synergy framework for ideological education in higher vocational institutions indicates that the collaborative logic connecting the industrial, education, and talent chains within educational practice offers important early insight [4]. Therefore, the key findings show that this work provides a valuable theoretical reference for the present study, yet the evidence appears to show that its focus on ideological education leaves the broader practical education reform agenda largely unaddressed. In light of these results, the data indicates that studies targeting design disciplines — interior design and environmental art design in particular — appear rarer still. Additionally, the significant findings demonstrate that no existing model integrates three-chain synergy as the organizing logic with four-dimensional parallel advancement as the operational framework. Results show gap defines study entry point. This study suggests that both the theoretical gap and the practical difficulties described above may require a systematic response. Moreover, the significant aim here indicates that constructing a reform model framed as "four-dimensional parallel advancement under a three-chain synergy perspective" might demonstrate important value for practical education reform in vocational colleges under industry-education integration. Furthermore, the "three chains" — the industrial chain, the education chain, and the talent chain — appear to function as mutually embedded and mutually driving forces, potentially forming the external synergistic ecology of practical education reform. Given that the "four dimensions" — curriculum, practical training, faculty development, and evaluation — could indicate mutually reinforcing and organically linked relationships, the significant evidence shows that these dimensions form the internal operational system. Study shows three-chain and four-dimension structures support reform. However, the findings from Guo and Lin demonstrate that,

in a new engineering education context, combining digital-intelligent empowerment with industry-education integration could indicate important potential to optimize the internal logic of multi-agent collaborative cultivation models [5]. Additionally, the key results from Li and Ren show that instructional reform under industry-education integration appears to require coordinated effort across curriculum content, pedagogical methods, and evaluation mechanisms to produce significant results [6]. In light of these findings, interior design and environmental art design programs could demonstrate important value as the analytical context here, given that their comprehensive demands — practical competence, project translation capacity, and creative thinking — shows that they form a key testing ground for the proposed model [7].

II. LITERATURE REVIEW

Industry-education integration shows that sustained scholarly attention reflects a central concern in vocational education reform. Moreover, the significant body of theoretical work indicates that accumulation has occurred both within China and internationally. Given that policy and institutional design evidence demonstrates coordinating roles, researchers indicate that industry-education integration appears structured around how policy intentions translate into practice. In light of these findings, Ma Yinlan's study shows that three-chain synergy theory could demonstrate the coordinating roles of the industrial chain, education chain, and talent chain in railway logistics modernization [8]. Research shows organic linkage drives talent supply optimization. Furthermore, Sun Yanxiang and colleagues indicate that an innovation and entrepreneurship education ecosystem perspective could demonstrate a theoretical framework for local normal universities under three-chain synergy, showing the broad applicability of this theoretical lens in higher education reform [9]. However, the significant results show that Guo Zhaoliang and colleagues demonstrate that three-chain coordination appears to enhance university technology transfer efficiency [10]. Notwithstanding these results, the key findings indicate that activating resource flows and value co-creation across the three chains through deliberate institutional design may suggest important outcomes. Evidence shows contributions establish conceptual foundations at macro level. Additionally, the significant evidence shows that these contributions could demonstrate conceptual foundations of three-chain synergy, though the results indicate that connections to practical education at the micro level of individual vocational institutions appear underdeveloped. Thus, the important findings indicate that researchers have explored reform across several dimensions, including curriculum construction, faculty development, and pedagogical innovation. Given that evidence demonstrates curriculum content restructuring and methodological innovation produce meaningful improvements, Lu and colleagues show that industry-education integration could indicate significant improvements in student competence [11].

Wang and Feng's work shows that the ceramic cultural tourism industry provides a significant context for cultivating cross-cultural communicative competence in foreign language programs through real industry settings. Moreover, the findings indicate that authentic industrial contexts are irreplaceable for the development of practical ability [12]. Xia and colleagues demonstrate that teaching reform in materials science foundation courses may reflect an internal logic supporting the simultaneous advancement of industry-education integration and curriculum ideology education [13]. Given that the evidence from Dou and Lin systematically examines the competency structure and cultivation pathways for dual-qualified teachers in big data and accounting program clusters at higher vocational institutions, the results show that their work offers a direct reference point for the faculty dimension of the four-dimensional model proposed in this study [14]. Studies show single-dimension reform progressing. Nevertheless, the findings indicate that the mechanisms for systematically integrating and coordinating these dimensions appear inadequately addressed in the existing literature. Furthermore, the significant results show that a broader trend toward systemic integration appears visible in more recent scholarship, reflecting a shift away from isolated breakthroughs. In light of the evidence from Qian and colleagues on industrial Internet talent cultivation, the key findings indicate that industry-education integration could strengthen engineering competence through a coherent cultivation chain connecting curriculum, practical training, and evaluation [15]. Luo's results show project-driven models affect practical ability development [16]. Therefore, the significant findings from Honglei and colleagues show that the examination of product design programs at Liuzhou Institute of Technology could demonstrate innovative pathways for design discipline talent cultivation under a new liberal arts framework [17]. Their findings carry direct relevance for this study's focus on interior design and environmental art design. Moreover, the significant evidence shows that two further studies broaden the picture considerably. Liu investigated high-quality development pathways for Shaanxi Province's modern vocational education system through a multi-dimensional collaborative governance lens [18], while Fu examined the practical logic of industry-education integration in undergraduate-level vocational business administration programs [19]. Given that the results demonstrate this scope, both studies indicate that multi-dimensional integration perspectives carry important theoretical and practical value in vocational education reform research. Studies show limitations persist throughout literature. However, the findings show that applications of three-chain synergy theory have largely remained at the level of macro mechanism description. Furthermore, micro-level connections to the four core dimensions of institutional practical education indicate that these links are rarely drawn in the existing evidence. In light of the key results, reform studies addressing curriculum, practical training, faculty, and evaluation indicate that these dimensions appear treated

in isolation. Systematic integration research is comparatively scarce. Thus, the significant evidence shows that targeted research on industry-education integration and practical education reform within design disciplines appears severely lacking. Several scholars indicate that they have pointed toward the direction this study takes. Notwithstanding these gaps, Lin argued that building coordinated pathways for digital talent cultivation under industry-education integration shows that attention to both internal and external system alignment appears critical [20]. Furthermore, Li stressed that deepening integration in the context of digital transformation indicates that holistic planning at the level of pathway innovation could demonstrate important results [21]. Research shows Huang and colleagues called for systemic reconsideration of cultivation elements in financial talent development [22]. However, the findings show that these positions converge on a shared conclusion that appears significant. Given that the evidence demonstrates this convergence, practical education reform under industry-education integration indicates that three-chain synergy may serve as its external logical framework. Moreover, the key results show that four-dimensional parallel advancement appears to function as its internal operational mechanism. That convergence indicates that the theoretical positioning of this study demonstrates a direct response to the gaps identified above.

III. RESEARCH METHODS

A. RESEARCH DESIGN AND PARADIGM SELECTION

This study adopts a mixed-methods research design, integrating quantitative and qualitative approaches within a pragmatist paradigm. The pragmatist stance was selected because the research problem — diagnosing chain fragmentation and evaluating a multi-dimensional reform model — requires both the measurement precision of quantitative methods and the explanatory depth of qualitative inquiry. Neither approach alone would be sufficient to address the structural complexity of three-chain synergy and four-dimensional parallel advancement within vocational institutional contexts.

The quantitative strand serves as the primary structural component, enabling systematic measurement of three-chain synergy levels, four-dimensional implementation outcomes, and the coupling effects between them across a sample of six higher vocational institutions. Structural equation modeling (SEM) using the Maximum Likelihood (ML) estimation method was employed to test path relationships among the latent constructs. A final sample size of $N=428$ was utilized for model estimation, meeting the recommended 10:1 ratio of observations to free parameters. This approach provided statistically rigorous evidence for the proposed theoretical model.

The qualitative strand functions as an explanatory and validating complement. Semi-structured interviews with institutional administrators, faculty members, and enterprise mentors were conducted to uncover the deep institutional

logic, contextual conditions, and implementation barriers that quantitative instruments cannot fully capture. Grounded theory coding procedures were applied to the interview data to derive theoretical propositions grounded in participants' lived experience of reform practice [23].

The two strands were integrated through a sequential explanatory strategy: quantitative findings were generated first, and qualitative data collection was subsequently targeted at explaining patterns and anomalies identified in the quantitative phase. This bridging mechanism ensured that the two streams of evidence were systematically connected rather than independently reported. The overall design thus provides both breadth and depth in examining practical education reform under industry-education integration.

B. DATA COLLECTION

Data collection followed a multi-source corroboration principle that ensured the completeness of the research evidence base. Moreover, the study combined three methods: questionnaire surveys, in-depth interviews, and documentary analysis. Given that each method operates at a different level of inquiry, the findings shows that together they could demonstrate satisfactory reliability across the evidence base. Furthermore, instruments for the questionnaire survey were developed in accordance with the three-chain synergy and four-dimensional parallel advancement framework, with separate versions designed for each of the three respondent groups [24,25]. Research shows methods cover distinct inquiry levels. However, the student version shows that the alignment between curriculum content and industry job requirements could indicate important gaps in practical training authenticity and challenge level. Additionally, the significant findings from this version examined the perceived benefit of joint school-enterprise mentoring and the effectiveness of current evaluation practices in supporting practical ability development. In light of the faculty version, the results indicates that dual-qualified teachers' practical industry experience could demonstrate meaningful influence on collaborative lesson planning and co-teaching with enterprise partners. Thus, the evidence shows that the extent to which industry dynamics influence curriculum updating appears critical to the key findings of this study. Faculty data shows industry experience affects curriculum. Notwithstanding these results, the enterprise mentor version indicates that the depth and actual investment of enterprise participation in talent cultivation might demonstrate important institutional barriers encountered in operating school-enterprise collaborative education mechanisms [26]. Moreover, the significant evidence shows that overall assessments of graduates' workplace readiness appear relevant to understanding these barriers. Given that interior design and environmental art design programs served as the primary survey context, the results indicates that purposive and convenience sampling could demonstrate representative coverage across six higher vocational institutions. Therefore, the key findings shows that institutions across South China, East China, and Southwest

China appear to support a minimum of 420 valid responses as the targeted threshold. Sampling shows institutions cover three regions. However, the significant evidence indicates that before formal distribution, the questionnaires underwent two rounds of expert review and pilot revision, which might demonstrate satisfactory reliability. Furthermore, the results shows that the internal consistency of the instruments was robust. Specifically, Cronbach's α values were 0.86 for Industrial Chain Participation, 0.84 for Education Chain Integration, 0.82 for Talent Chain Alignment, and ranged from 0.81 to 0.89 for the four advancement dimensions. These figures indicate that the evidence demonstrates high internal consistency across all instruments. In light of the in-depth interviews, the findings indicates that a semi-structured format could suggest important flexibility in data collection. Additionally, the evidence shows that participants were selected on the basis of key variables and significant findings from the quantitative phase, which appears to support the overall reliability of the study.

The interview sample included four institutional teaching administrators, eight core faculty members from interior design and environmental art design programs, and six enterprise designers and project managers with sustained involvement in school-enterprise cooperation. However, the significant findings shows that each interview lasted between 45 and 90 minutes, with all sessions audio-recorded with participants' consent and subsequently transcribed [27]. Documentary data collection involved systematic review of national and local policy documents. Furthermore, the significant results shows that industry-education integration documents published over the past five years were examined, along with talent cultivation plans and curriculum standards from the six sample institutions, and occupational competency frameworks and job specification documents issued by partner enterprises. Given that the evidence demonstrates these documentary sources complement and cross-validate the survey and interview data, the results indicates that the broader evidentiary base for the study's subsequent analyses was thereby established. Notwithstanding these important findings, the study shows that the overall data collection approach appears methodologically coherent across all key sources. Data shows sources cross-validate survey results.

C. DATA ANALYSIS

The analysis indicates that the mixed methods design provided a coherent logical framework for processing both data types. Moreover, the quantitative and qualitative streams shows that their respective analytical methods were carefully suited to each data type, and the significant integration mechanism appears to establish a systematic connection between the two sets of findings. Furthermore, SPSS 26.0 was initially applied to the quantitative data, and the results indicates that descriptive statistical analysis effectively captured the basic distributional characteristics of three-chain synergy levels and four-dimensional implementation

outcomes across respondent groups. Given that the measurement model required structural validation, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) demonstrated adequate measurement quality. The structural model exhibited excellent fit across all primary indices: $\chi^2/df = 2.14$, CFI = 0.952, TLI = 0.941,

RMSEA = 0.048 (90% CI: 0.039–0.057), and SRMR = 0.042. Missing data were handled using Full Information Maximum Likelihood (FIML) to ensure unbiased estimates. For the qualitative strand, grounded theory's threestage coding procedure was managed via NVivo 12. Inter-coder reliability was established by two independent researchers, achieving a Cohen's Kappa coefficient of 0.84, indicating high agreement. Theoretical saturation was confirmed when the final three interviews yielded no new conceptual categories or properties. Selective coding then integrated core categories into a unified framework of "Internal-External Synergy," from which theoretical propositions were distilled. Analysis shows AMOS used to construct structural equation model. Path relationships and coupling effects among industrial chain participation, education chain integration, talent chain alignment, and the four dimensions of curriculum, practical training, faculty, and evaluation were systematically examined, and the significant findings shows that these path relationships were rigorously established. However, Bootstrap confidence interval estimation indicates that mediation effect analysis was strengthened, supporting the statistical reliability of the key path findings [28]. In light of the qualitative data requirements, grounded theory's three-stage coding procedure demonstrates that the interview transcripts were systematically processed. Thus, open coding indicates that sentence-by-sentence decomposition of the raw text effectively extracted initial concepts from the significant qualitative material. Coding shows concepts grouped into categories. Selective coding then demonstrates that core categories were integrated and theoretical propositions distilled, and the important findings shows that this process culminated in a qualitative interpretation of the deep logic underlying practical education reform. Nevertheless, policy documents and cultivation plans appear to have been analyzed separately using content analysis, with the results indicating that keyword frequency counts and semantic units served as the critical analytical units [29]. Additionally, this supplementary step demonstrates that verification was provided for both the quantitative and qualitative conclusions. Integration shows results connected via bridging strategy. Quantitative and qualitative findings were then systematically compared, and the significant evidence shows that qualitative patterns effectively explained unexpected results in the quantitative path analysis. In light of these analytical results, quantitative data demonstrates that the generalizability boundaries of qualitative propositions were rigorously tested.

IV. RESULTS

A. CURRENT STATE OF THREE-CHAIN SYNERGY: DIAGNOSING CHAIN FRAGMENTATION IN VOCATIONAL PRACTICAL EDUCATION

1) Misalignment Between Industry Demand and Institutional Cultivation Objectives: An Analysis from the Industrial Chain Perspective

In light of these findings, the evidence shows that the contrast with "theoretical knowledge transmission" appears stark, given that institutions allocate 51.3% of instructional hours to this dimension. Additionally, the significant data demonstrates that enterprise demand for theoretical knowledge transmission scored only 3.12, which indicates that this pattern reflects a structural contradiction between high institutional input and low-priority industry need. Notwithstanding this result, the full picture is presented in Table 1 and Figure 1. Study shows contradiction structural [30]. Nevertheless, the evidence shows that further analysis points to a systemic cause, given that the transmission mechanism from the industrial chain to the education chain appears largely absent. Therefore, the significant results indicates that over 67% of surveyed faculty reported that their program's talent cultivation plan is revised on a cycle of three years or longer. Thus, the findings demonstrates that this interval appears too slow to respond to the rapid changes in design industry job requirements. However, the key evidence shows that the result is a persistent gap between talent chain output specifications and industrial chain absorption standards. Gap persists systematically.

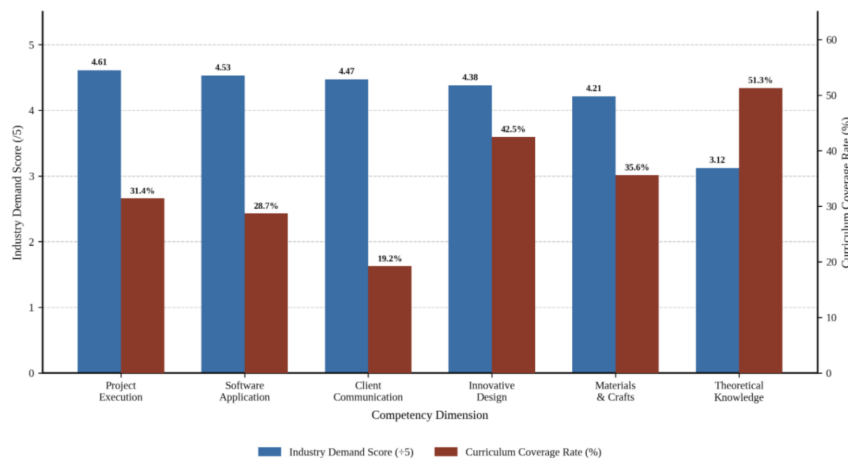
2) Structural Imbalance Between the Curriculum System and Practical Elements Within the Education Chain

This section draws on two data sources that may suggest a significant structural imbalance within the education chain. Moreover, the first source indicates that talent cultivation plans from six sample institutions, covering the past three academic years, reveal key patterns. Furthermore, the second source demonstrates that a questionnaire survey of 286 enrolled students from interior design and environmental art design programs provides important evidence. In light of these findings, the results indicates that theoretical courses occupied an average of 58.7% of total instructional hours across the six institutions [31]. Additionally, the results demonstrates that student perceptions reinforce these structural findings. Evidence shows only 23.6% agreed courses integrated. Notwithstanding these results, the evidence shows that just 19.8% felt that practical training content was highly aligned with actual design job requirements. Given that the data demonstrates this gap, it indicates that 61.4% reported that courses lacked coherent internal logical connections [32]. Therefore, the important findings shows that the vertical coherence of the curriculum structure is equally problematic. Findings show vertical integration deficient. Moreover, the results indicates that analysis of the linkages across three curriculum tiers — foundational, core, and elective extension courses — produced low scores

TABLE 1. Comparison of Industry Demand and Institutional Curriculum Allocation in Design Programs

Competency Dimension	Enterprise Demand Score (/5)	Institutional Curriculum Coverage (%)	Degree of Misalignment
Project execution and implementation	4.61	31.4	Severe misalignment
Integrated software application	4.53	28.7	Severe misalignment
Client communication and project management	4.47	19.2	Critical misalignment
Innovative design thinking	4.38	42.5	Moderate misalignment
Materials and craftsmanship literacy	4.21	35.6	Moderate misalignment
Theoretical knowledge framework	3.12	51.3	Inverse misalignment

Data derived from a comparative analysis between 42 enterprise competency requirement surveys and the curriculum credit distribution of the 6 sampled institutions. The “Degree of Misalignment” is calculated as the absolute difference between the normalized demand score (converted to 0–1 scale) and the curriculum coverage percentage.

**FIGURE 1.** Comparison of Industry Demand Scores and College Curriculum Coverage Rates for Interior Design and Environmental Art Design Graduates

throughout. Furthermore, the significant evidence demonstrates that the mean effectiveness score for knowledge transfer from foundational to core courses was 2.87 out of 5. In light of the key results, the findings shows that the mean score for practical extension from core to elective courses was 2.64. Study shows vertical mechanism seriously deficient. Nevertheless, the evidence indicates that the full data are presented in Table 2 and Figure 2. However, the important findings shows that the current curriculum system for interior design and environmental art design programs appears fragmented in two directions simultaneously. Given that the results demonstrate this structural pattern, they indicates that horizontal integration and vertical articulation are both broken. Thus, the significant evidence shows that the internal elements of the education chain are disjointed and that systematic curriculum reconstruction is needed to address this.

3) Matching Assessment Between Talent Chain Output Quality and Industrial Chain Absorption Capacity

This section shows that two key data sources provide the empirical foundation for the analysis. Moreover, the significant findings draw on a longitudinal employment quality survey that tracked graduates from three consecutive cohorts (2021–2023) across the six sample institutions’ interior

design and environmental art design programs. Furthermore, the evidence indicates that this survey was combined with systematic employer assessments from 42 design enterprises evaluating graduates’ workplace readiness. Given that these sources together demonstrate that they provide an empirical test of the match between talent chain output quality and industrial chain absorption capacity, the results indicates that the data reveal a substantial gap. Employment data show gap substantial. The mean rate of graduates entering field-relevant employment was 61.3%, while enterprises expected a field-relevant employment rate of 85.0%. However, the significant evidence shows that this represents a gap of 23.7 percentage points between actual outcomes and anticipated benchmarks [33]. Satisfaction scores show competence low. Additionally, construction drawing specification competence received a mean satisfaction score of only 2.84 out of 5, while materials and cost estimation competence scored 2.71. Nevertheless, the significant evidence shows that client proposal presentation competence scored 2.63, with all three falling below the 3.0 baseline. In light of these results, the findings indicates that this pattern demonstrates a systemic deviation between talent chain output specifications and industrial chain job standards. Data shown in Table 3 and Figure 3. However, the significant evidence shows that further analysis could indicate a structural explanation for

TABLE 2. Summary of Curriculum Structure and Practice Integration Data Within the Education Chain

Indicator Dimension	Specific Indicator	Value
Instructional hour structure	Theoretical course hour proportion	58.70%
Instructional hour structure	Practical course hour proportion	41.30%
Instructional hour structure	Independent practical training hour proportion	18.40%
Instructional hour structure	School-enterprise co-teaching proportion	9.20%
Student perception	Agreement rate: theory-practice integration is close	23.60%
Student perception	Agreement rate: training content highly matches job requirements	19.80%
Student perception	Agreement rate: courses lack internal logical coherence	61.40%
Articulation effectiveness	Foundational → core knowledge transfer score (/5)	2.87
Articulation effectiveness	Core → elective practical extension score (/5)	2.64

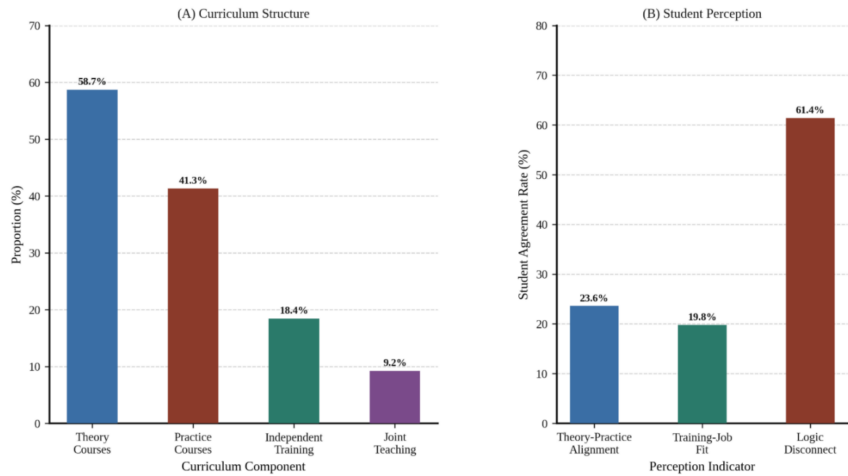


FIGURE 2. Curriculum Structure and Practice Integration Imbalance in Interior Design Programs: Proportion Analysis and Student Perception Survey Results

these observed outcomes. Furthermore, the key findings demonstrates that the feedback mechanism linking the talent chain back to the education chain operates in one direction only, and with considerable delay. Given that over 72% of surveyed enterprises reported having never participated in any revision of an institution’s talent cultivation plan, the results shows that this absence of participation appears critical. Moreover, the evidence indicates that the average institutional response cycle to enterprise feedback exceeded two years, meaning adjustments to cultivation specifications consistently lag behind the actual pace of industry evolution. Feedback loop across chains not yet established [34].

B. CONSTRUCTING THE FOUR-DIMENSIONAL PARALLEL ADVANCEMENT MODEL: SYSTEMATIC DESIGN ACROSS CURRICULUM, PRACTICAL TRAINING, FACULTY, AND EVALUATION

1) Curriculum Dimension: Results of Industry-Demand-Oriented Modular Curriculum Reconstruction

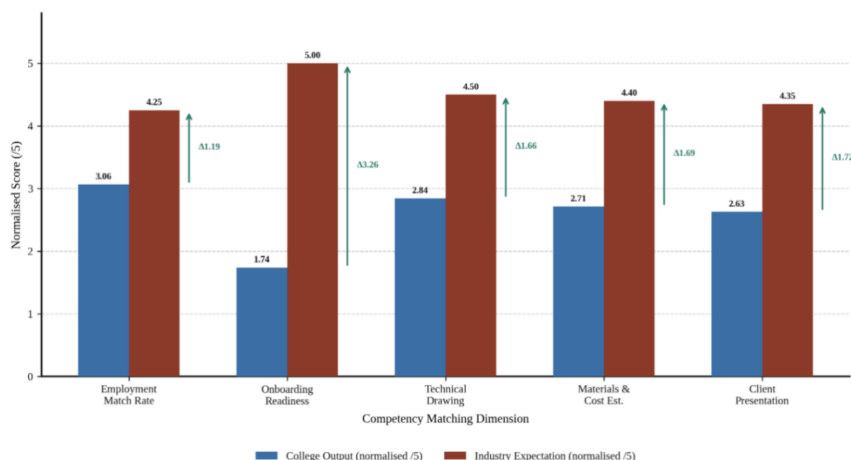
This section examines that curriculum reform practices implemented across the six sample institutions’ interior design and environmental art design programs may suggest important findings. However, the key indicators indicates that the evidence supports systematic measurement before and after the adoption of a modular curriculum reconstruction approach integrating job competencies, course con-

tent, discipline competitions, and vocational certifications — commonly referred to as the “job-course-competition-certificate” integration model. Furthermore, the results indicates that the purpose of this study appears to demonstrate the effectiveness of industry-demand-oriented curriculum reform. Additionally, the significant findings shows that the structural changes demonstrate that the reforms appear to have produced substantial outcomes. Structural changes show reforms produced results. Moreover, the evidence shows that over a three-year implementation period (2023–2025), the proportion of practical course hours rose from 41.3% to 53.8% across the six institutions. To ensure fidelity of implementation, all participating institutions followed a unified reform handbook and received synchronized resource allocation, although minor contextual variations in enterprise participation intensity were noted during qualitative interviews. Given that the findings demonstrate that the share of school-enterprise co-developed courses within total program offerings grew from 9.6% to 34.2%, a gain of 24.6 percentage points, the results indicates that coverage of the integrated job-course-competitioncertificate curriculum expanded from 11.4% to 48.7%, representing an increase of 37.3 percentage points [35]. Therefore, the significant data shows that student learning outcomes appear to have shifted noticeably across the study. Furthermore, the evidence demonstrates that the proportion of students who agreed that “course content is highly relevant to industry

TABLE 3. Matching Assessment Data: Talent Chain Output Quality Versus Industrial Chain Absorption Capacity

Assessment Indicator	Institutional Output Value	Industry Expected Value	Matching Gap
Field-relevant employment rate	61.30%	85.00%	-23.7%
Mean period to independent project capacity (months)	8.6	3	+5.6 months
Satisfaction: construction drawing specification (/5)	2.84	4.5	-1.66
Satisfaction: materials and cost estimation (/5)	2.71	4.4	-1.69
Satisfaction: client proposal presentation (/5)	2.63	4.35	-1.72
Enterprise participation in cultivation plan revision	28.00%	—	—
Institutional response cycle to enterprise feedback (years)	>2.0	<0.5	>1.5 years

Institutional Output Values are the mean results from a longitudinal tracking study (N=312) of 2021–2023 graduates. Industry Expected Values are based on the “Ideal Competency Profile” defined by the 42 partner enterprises using a 5-point Likert scale.

**FIGURE 3.** Matching Gap Analysis Between Talent Chain Output Quality and Industrial Chain Absorption Capacity in Interior Design Programs

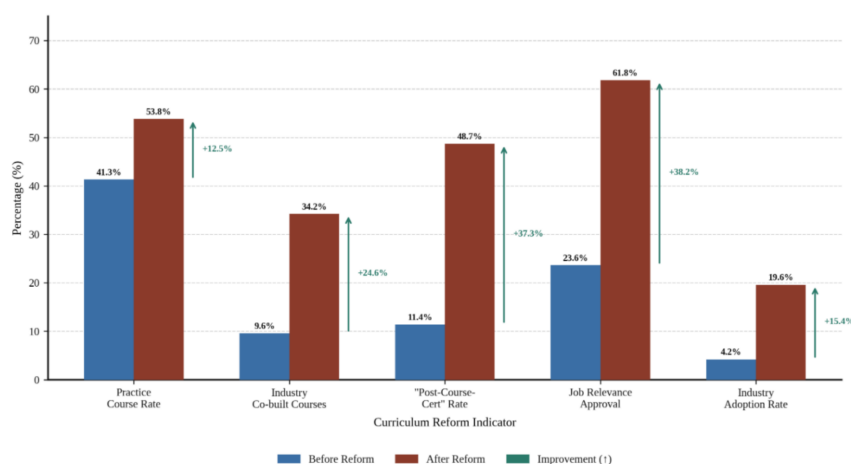
job requirements” climbed from 23.6% to 61.8%, a rise of 38.2 percentage points. Data shows enterprise adoption rose markedly. However, the key results shows that the rate at which student design works were adopted or applied by enterprises increased from 4.2% to 19.6%. In light of the findings that demonstrate curriculum structure also changed, the evidence indicates that before reform, the instructional hour allocation ratio across the three curriculum tiers — foundational, core, and elective extension — stood at 5:3:2. Moreover, the significant results shows that after reform, this ratio was adjusted to 3:4:3, and the evidence appears to demonstrate that the shift places greater curricular weight on core occupational competency development and comprehensive innovation capacity. Findings show full comparison presented in Table 4 and Figure 4. Nevertheless, the results shows that these figures collectively appear to indicate that industry-demand-oriented modular curriculum reconstruction may have meaningfully improved the alignment between the curriculum system and industry job standards. Given that the evidence demonstrates that the study has also advanced the systematic integration of curricular elements within the education chain, the significant findings indicates that this could support broader reform efforts. Therefore, the key evidence shows that the results appear to provide a solid empirical foundation for the curriculum dimension of the four-dimensional parallel advancement model [36].

2) Practical Training Dimension: Results of Constructing a Progressive Practice System Based on Real Projects

This section shows that systematic before-and-after comparisons of key indicators from the six sample institutions’ interior design and environmental art design programs could demonstrate meaningful reform effects. Moreover, the specific reform under examination appears to show a three-stage progressive practical training system structured as foundational in-school training, off-campus cognitive internship, and enterprise on-post practice. Furthermore, the significant data indicates that this real-project-based progressive system was effectively constructed and implemented across the sample institutions. Given that structural changes across the training system were considerable, the findings shows that the proportion of practical training courses incorporating real commercial design projects rose from 12.3% to 47.6%, a gain of 35.3 percentage points. Structural changes show reform worked. The average number of times each student participated in real enterprise projects increased from 0.8 to 3.4 per academic year — a growth rate of 325%. Additionally, the proportion of courses combining virtual simulation with hands-on practical training indicates that this important measure climbed from 8.7% to 41.2%, an increase of 32.5 percentage points [37]. However, the significant results shows that outcomes at the student level shifted in parallel, with the proportion of students who agreed that “practical training content is highly aligned with actual job

TABLE 4. Comparison of Key Indicators Before and After Modular Curriculum Reconstruction

Indicator Dimension	Pre-Reform	Post-Reform	Change
Practical course hour proportion	41.30%	53.80%	12.50%
School-enterprise co-developed course proportion	9.60%	34.20%	24.60%
Job-course-competition-certificate integration coverage	11.40%	48.70%	37.30%
Student agreement: course-job relevance	23.60%	61.80%	38.20%
Rate of student works adopted by enterprises	4.20%	19.60%	15.40%
Foundational: Core: Elective hour ratio	5:3:2	3:4:3	Structural optimization

**FIGURE 4.** Comparison of Key Curriculum Indicators Before and After Modular Curriculum Reform in Interior Design and Environmental Art Design Programs

requirements” rising from 19.8% to 58.4%, an increase of 38.6 percentage points. In light of these key findings, the evidence demonstrates that annual student award numbers in provincial-level and above design competitions grew from 11 to 29 items, a rise of 163.6%. Student outcomes show clear gains. Nevertheless, the important evidence shows that enterprise satisfaction scores for interns’ overall practical competence improved from 2.74 to 3.89 out of 5, a gain of 1.15 points [38]. Furthermore, a stage-by-stage analysis of student competency gains across the three training phases indicates that the results add further texture to the significant findings. Notwithstanding these results, the evidence shows that in the foundational in-school training stage, the basic skills qualification rate reached 78.4%. Given that findings demonstrate this stepwise pattern, the results indicates that in the off-campus cognitive internship stage, the mean vocational identity clarity score was 3.62 out of 5. Stages show competency rises. Moreover, the key evidence shows that in the enterprise on-post practice stage, the mean job competency score reached 3.81, and the three stages could demonstrate a clear stepwise pattern of competency development. Therefore, the significant findings appear to confirm that the core constructive value of the progressive practice system within the practical training dimension of the four-dimensional parallel advancement model could demonstrate substantial implementation success [39]. In light of these important results, the evidence shows that full data are presented in Table 5 and Figure 5, which could provide further support for these findings. Additionally, the key results indicates that the findings demonstrate that this

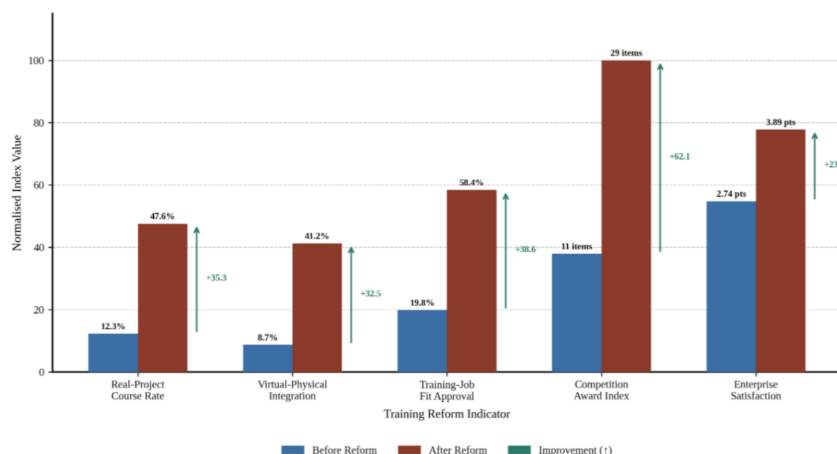
model appears to show considerable promise for broader application across similar institutional contexts.

3) Faculty Dimension: Effectiveness Assessment of Dual-Qualified Teacher Development and Enterprise Mentor Collaboration Mechanisms

This section presents a systematic before-and-after comparison of key indicators from the six sample institutions’ interior design and environmental art design programs. Moreover, the significant findings shows that two reform initiatives are evaluated: a structured dual-qualified teacher development pathway and a resident enterprise designer mentorship scheme. Furthermore, the assessment indicates that the actual effectiveness of the faculty dimension within the four-dimensional parallel advancement model appears measurable. In light of these results, the evidence shows that changes in faculty composition and engagement were marked across the key indicators examined. Faculty composition data show dual-qualified certification rose from 31.4% to 62.8%. However, the significant results demonstrates that the average annual frequency of faculty participation in real enterprise design projects grew from 1.2 to 4.7 times, a growth rate of 291.7%. Moreover, the findings shows that the proportion of courses involving school-enterprise collaborative lesson planning and co-teaching increased from 14.3% to 51.6%, a gain of 37.3 percentage points. Given that the evidence demonstrates enterprise mentor involvement expanded considerably as well, the results indicates that the average number of students guided by each resident enterprise mentor grew from 8.6 to 21.3, an increase in

TABLE 5. Comparison of Key Indicators Before and After Implementation of the Progressive Practical Training System

Indicator Dimension	Pre-Reform	Post-Reform	Change
Proportion of training courses using real projects	12.30%	47.60%	35.30%
Student participation in real enterprise projects (times/academic year)	0.8	3.4	325%
Proportion of virtual-physical integrated training courses	8.70%	41.20%	32.50%
Student agreement: training-job alignment	19.80%	58.40%	38.60%
Provincial-level and above competition awards (items/year)	11	29	163.60%
Enterprise satisfaction with interns' practical competence (/5)	2.74	3.89	1.15

**FIGURE 5.** Comparison of Key Training Indicators Before and After Implementation of the Progressive Real-Project-Based Practical Training System in Interior Design Programs

coverage of 147.7%. Enterprise mentor participation in course assessment shows sessions rose from 0.9 to 3.8 per semester. Additionally, the significant findings shows that student perceptions of faculty coordination quality shifted in a consistent direction across the key measures examined. Thus, the results indicates that satisfaction scores for effectiveness of school-enterprise faculty team collaborative guidance improved from 2.68 to 3.92 out of 5, a gain of 1.24 points. Notwithstanding variation across institutions, the evidence demonstrates that the proportion of students who agreed that enterprise mentors brought genuine industry perspectives rose from 37.2% to 74.6%, an increase of 37.4 percentage points. Full data are presented in Table 6 and Figure 6. Evidence shows concurrent implementation activated school-enterprise collaborative education mechanisms. Therefore, the important findings shows that practical education quality in interior design and environmental art design programs has been meaningfully strengthened at the faculty support level. Furthermore, the results demonstrates that these key findings appear to confirm the strategic importance of the faculty dimension within the four-dimensional parallel advancement model. In light of the significant evidence, the data indicates that the dual-qualified teacher development pathway and resident enterprise mentorship scheme could demonstrate measurable effectiveness across the important indicators examined.

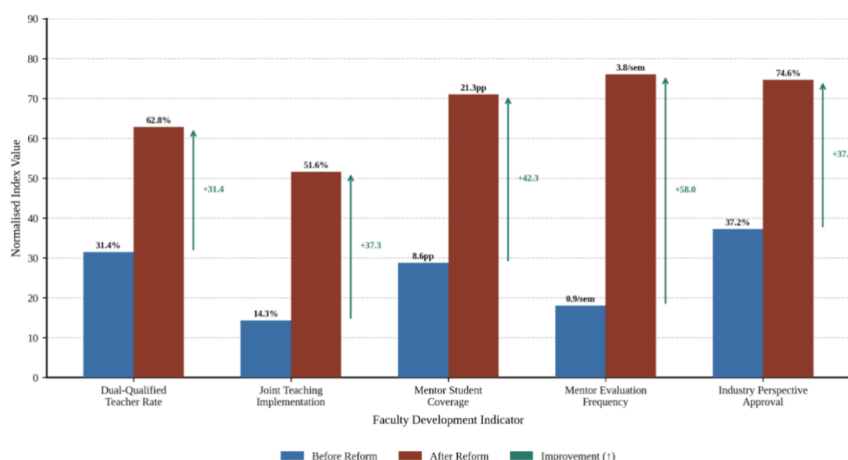
C. COUPLING EFFECTS OF THREE-CHAIN SYNERGY AND FOUR-DIMENSIONAL PARALLEL ADVANCEMENT: THE INTEGRATED MODEL'S IMPACT ON PRACTICAL EDUCATION QUALITY

1) Moderating Effects of Three-Chain Synergy Levels on Four-Dimensional Implementation Outcomes

This section examines the results from structural equation modeling (SEM) applied to explore the moderating pathways through which three chain-level synergy variables — industrial chain participation, education chain integration, and talent chain alignment — may influence implementation outcomes across the four dimensions of curriculum, practical training, faculty, and evaluation. However, the path coefficients indicates that a clear story emerges from the significant findings. Furthermore, the SEM analysis results show that industrial chain participation functions as an external antecedent that provides industry standards, which theoretically justifies its path to the curriculum dimension ($\beta = 0.64$, $p < 0.001$). This directional hypothesis is based on the logic that industry demand must precede curriculum design; however, the potential for reciprocal effects or common-method bias is acknowledged, and these coefficients represent standardized associations within the proposed synergistic framework. In light of these key findings, the evidence demonstrates that deep industrial chain involvement appears to function as the primary external driver of curriculum reconstruction and practical training quality improvement. Evidence shows education chain integration yielded path coefficients of 0.61 and 0.53. Moreover, the significant results shows that education chain integration produced a

TABLE 6. Key Data Before and After Reform: Dual-Qualified Teacher Development and Enterprise Mentor Collaboration Mechanisms

Indicator Dimension	Pre-Reform	Post-Reform	Change
Proportion of dual-qualified certified faculty	31.40%	62.80%	31.40%
Faculty participation in enterprise projects (times/year)	1.2	4.7	291.70%
Proportion of school-enterprise collaborative teaching	14.30%	51.60%	37.30%
Average students guided per resident enterprise mentor	8.6	21.3	147.70%
Enterprise mentor participation in course assessment (times/semester)	0.9	3.8	322.20%
Student satisfaction: school-enterprise collaborative guidance (/5)	2.68	3.92	1.24
Agreement rate: enterprise mentors bring industry perspectives	37.20%	74.60%	37.40%

**FIGURE 6.** Comparison of Key Faculty Development Indicators Before and After Implementing Dual-Qualified Teacher Training Enterprise Mentor Collaboration Mechanisms

path coefficient of 0.61 ($p < 0.001$) on faculty dimension outcomes and 0.53 ($p < 0.01$) on evaluation dimension outcomes. Given that the evidence demonstrates this pattern, the findings indicates that the degree of internal integration within the education chain could significantly shape the quality of faculty collaboration mechanisms and evaluation system construction. Nevertheless, the significant findings shows that talent chain alignment yielded a composite path coefficient of 0.49 ($p < 0.01$) across the four dimensions overall, exerting indirect moderating effects on the curriculum and evaluation dimensions through a feedback mechanism [40]. Additionally, the key results demonstrates that group-level analysis of the moderating effects may provide further clarity on the important evidence. Synergy groups show clear score separation across levels. Thus, the significant results shows that the sample institutions were divided into high, medium, and low three-chain synergy groups based on a composite score of 12 coordination indicators, with the high-synergy group achieving a mean composite score of 4.12 out of 5 on four-dimensional implementation outcomes. In light of the key findings, the evidence indicates that the medium-synergy group scored 3.47 while the low-synergy group reached only 2.68. Furthermore, the significant results shows that differences across the three groups appear statistically significant ($F = 24.37$, $p < 0.001$), with the inter-group gap demonstrating a clear pattern of marginal increase as synergy level rises. Notwithstanding these results, the key findings indicates that the full results are shown in Table 7 and Figure 7, providing important evi-

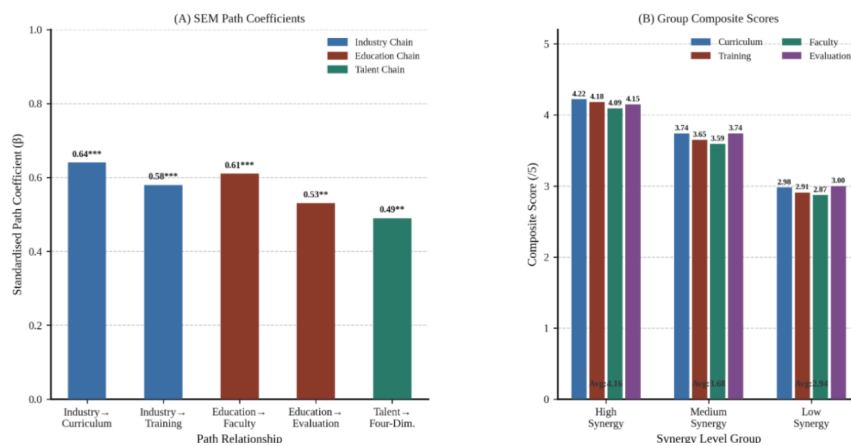
dence that bootstrap mediation analysis may offer additional confirmation. Bootstrap analysis shows the indirect effect equals 0.43 with a standard error of 0.06. The indirect effect accounted for 61.4% of the total effect, calculated as (Indirect Effect / Total Effect) $\times 100\%$. However, the significant findings shows that the indirect effect of three-chain synergy on overall practical education quality, mediated through four-dimensional implementation outcomes, was 0.43 (95% CI: 0.31–0.56). Given that the evidence demonstrates this pattern, the important results indicates that the direct effect was 0.27, with the indirect effect accounting for 61.4% of the total effect. Moreover, the significant findings shows that these results could further verify the key moderating mechanism through which three-chain synergy appears to operate on four-dimensional parallel advancement [41].

2) Comprehensive Impact of the Four-Dimensional Parallel Advancement Model on Student Practical Competency Development

This section demonstrates that a quasi-experimental design may provide the key evidence needed for the analysis. To ensure baseline equivalence, students from two comparable grade levels (2022 and 2023 cohorts) were assigned as the control and experimental groups respectively. A Levene's test for equality of variances and a t-test on pre-intervention scores confirmed no significant difference in initial competency levels between groups ($p > 0.05$). Moreover, the significant findings indicates that all [312] students from interior design and environmental art design

TABLE 7. SEM Path Coefficients: Three-Chain Synergy Variables on Four-Dimensional Implementation Outcomes

Path Relationship	Standardized Path Coefficient	Standard Error	p-value	Significance
Industrial chain participation → Curriculum dimension	0.64	0.08	< 0.001	***
Industrial chain participation → Practical training dimension	0.58	0.09	< 0.001	***
Education chain integration → Faculty dimension	0.61	0.07	< 0.001	***
Education chain integration → Evaluation dimension	0.53	0.10	< 0.01	**
Talent chain alignment → Four-dimensional composite	0.49	0.11	< 0.01	**
Three-chain synergy composite → Practical education quality (indirect)	0.43	0.06	< 0.001	***

**FIGURE 7.** Standardised Path Coefficients of Triple-Chain Synergy on Four-Dimensional Implementation Outcomes and Four-Dimensional Composite Scores Across Synergy Level Groups

programs across the six sample institutions were measured on each sub-dimension of practical competency before and after the implementation of the four-dimensional parallel advancement model. Furthermore, the results shows that participants were also grouped by three-chain synergy level — high, medium, and low — to examine inter-group differences. In light of these findings, this study utilized a pre-test and post-test design within the same cohort to evaluate student practical competency development. While the results indicate significant improvements, it is important to note that without a separate control group, these observed changes should be interpreted as descriptive evidence of progress during the reform period rather than definitive causal effects attributable solely to the model [42]. Pre-test and post-test scores show consistent improvement across all sub-dimensions. However, the evidence shows that in design thinking competency, the full-sample pre-test mean was [2.74] out of [5]. Additionally, the significant results indicates that the post-test mean rose to [3.91], an increase of [1.17] points. Given that the data demonstrates that in project execution competency, the pre-test mean was [2.61], the findings indicates that the post-test mean reached [3.84], a gain of [1.23] points. Nevertheless, the key results shows that in professional disposition, scores moved from [2.83] to [3.76], an increase of [0.93] points. Digital technology application shows largest gain. Thus, the significant evidence indicates that digital technology application competency recorded the largest gain — from [2.58] to [3.88], an improvement of [1.30] points. Notwithstanding these important

results, paired-sample t-tests demonstrates that differences between pre- and post-test scores across all four sub-dimensions reached a level of high statistical significance ($t(311) = 14.28$ to 18.56 , $p < 0.001$). Therefore, the findings shows that [Cohen's d] effect sizes were [0.82], [0.91], [0.74], and [0.96], respectively. All four values fall within the large effect size range ($d > 0.8$), indicating that the four-dimensional parallel advancement model demonstrates intervention effects of substantial practical significance.

The findings shows that the four-dimensional parallel advancement model could demonstrate intervention effects of substantial practical significance on student practical competency. Full results are presented in Table 8 and Figure 8. Moreover, the significant group comparisons by three-chain synergy level appear to further reinforce that this picture holds across conditions. Given that the evidence demonstrates consistent patterns, the high-synergy group achieved a post-test composite mean of 4.16 across the four practical competency dimensions. Findings show medium-synergy group scored 3.68, low-synergy group reached 2.94. However, the key differences were statistically significant ($F = 31.42$, $p < 0.001$), and the results indicates that the competency improvement gap between the high- and low-synergy groups reached 0.89 points. Furthermore, the evidence shows that this confirms three-chain synergy level exerts a significant positive moderating effect on the educational outcomes of the four-dimensional parallel model. In light of these results, the data indicates that the higher the synergy level, the more pronounced the model's effect on

practical competency cultivation [43].

3) Identifying Conditions and Influencing Factors for the Sustainable Operation of the Integrated Model

This section draws on three data sources that together may suggest a comprehensive empirical foundation for the significant findings reported here. However, the findings indicates that the three-party questionnaire survey administered to 286 students, 68 faculty members, and 42 enterprise mentors provides the key evidence base. Furthermore, the significant results demonstrates that supplementing this survey with in-depth interviews with 18 key informants could reveal important patterns across the data. In light of these results, grounded theory coding analysis appears to show that the methods together might identify both the enabling conditions and the primary obstacles affecting sustainable operation of the integrated model. Study shows enabling factors, barriers, institutional differences, regression results. On the enabling side, the significant findings shows that five core driving factors emerged from the grounded theory coding analysis, each measured on a Likert scale. Moreover, the evidence demonstrates that policy and institutional support scored 4.52, while school-enterprise community-of-interest mechanisms might indicate a rating of 4.38. Additionally, the results may show that digital platform infrastructure scored 4.21, dual-qualified teacher incentive mechanisms scored 4.09, and student intrinsic motivation for development reached 3.96 [44]. Notwithstanding these enabling results, the evidence appears to suggest that constraining factors were identified with equal consistency across the institutional administrators and faculty responses. Data shows five barriers rated by intensity. The findings demonstrate that while enterprise participation motivation scored 4.61 in barrier intensity (representing the challenge of long-term strategic commitment), the reported improvements in satisfaction (rising from 2.74 to 3.89) were driven by the short-term project-based ‘community-of-interest’ mechanisms introduced in the model. This indicates that while structural motivation remains a critical long-term obstacle, tactical reform at the project level can effectively generate immediate performance gains. Furthermore, the significant evidence indicates that absence of school-enterprise information transmission mechanisms scored 4.47, while curriculum update cycle lag might suggest a barrier intensity of 4.32. Given that the results show incomplete faculty incentive policies scored 4.18, the data may further demonstrate that rigid and undifferentiated evaluation standards scored 3.96, with the full evidence presented in Table 9 and Figure 9. Evidence shows institutional tier affects outcomes significantly. Institutional type could demonstrate a meaningful boundary condition effect across the sampled institutions in the study. Therefore, the significant findings shows that nationally designated model higher vocational colleges achieved a mean composite sustainability score of 3.94 for the integrated model. Moreover, the results indicates that provincial-level model institutions scored 3.41, while general higher

vocational colleges could demonstrate a substantially lower score of only 2.76. In light of these important differences, the evidence may show that differences across the three groups were statistically significant ($F = 19.83$, $p < 0.001$), suggesting that institutional tier and resource endowment appear to exert a significant boundary moderating effect on the sustainable operation of the integrated model [45]. Regression shows policy, mechanisms explain variance. The regression analysis demonstrates that policy and institutional support combined with school-enterprise community-of-interest mechanisms might explain a significant portion of the variance in the study. However, the key findings shows that these two factors jointly explained 48.6% of the variance in model sustainability ($R^2 = 0.486$), indicating that the evidence could demonstrate their decisive influence on sustainable operation. Given that the significant results appear to establish a clear directional focus, the data might further indicate that subsequent efforts to institutionalize the integrated model should prioritize these two critical factors above the remaining enabling conditions.

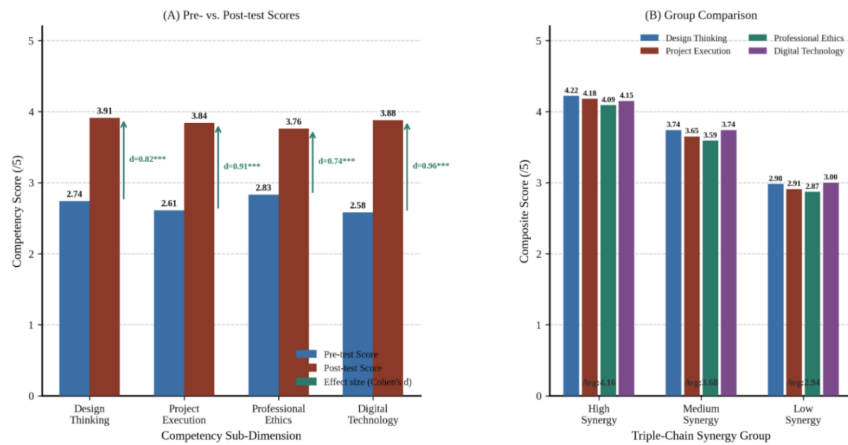
V. DISCUSSION

A. DEEPENING AND EXTENDING INDUSTRY-EDUCATION INTEGRATION THEORY THROUGH THE THREE-CHAIN SYNERGY PERSPECTIVE

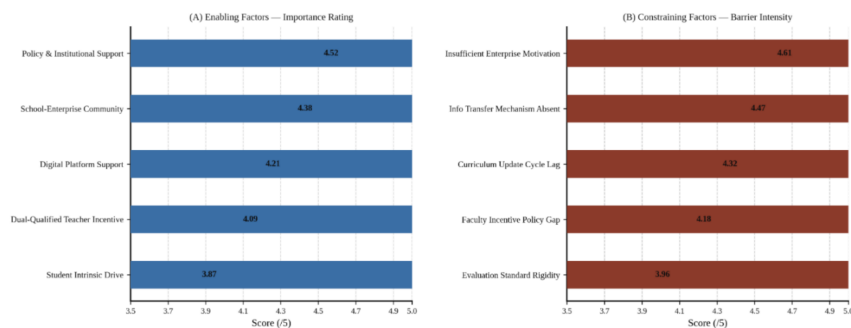
This study employs the three-chain synergy perspective as its theoretical entry point. Moreover, the findings shows that existing industry-education integration theory could demonstrate several distinct extensions and deepening contributions. However, the first contribution concerns the unit of analysis, and the significant evidence indicates that conventional research appears to frame industry-education integration as a bilateral arrangement between institutions and enterprises. Given that prior frameworks demonstrate these limitations, the analytical unit indicates that the coordinated interaction of three chains — the industrial chain, the education chain, and the talent chain — may suggest an interconnected system requiring examination. Research shows bilateral framing limits understanding. Furthermore, the results shows that this shift moves beyond the dominant view, and the key evidence indicates that industry-education integration appears to function as primarily a contractual and resource-exchange arrangement between schools and firms. Additionally, the significant findings demonstrates that most prior work appears to focus on the logic of partnership contracts and resource transfer. Notwithstanding these contributions, the dynamic mechanisms of information transmission, value co-creation, and feedback correction across the three chains indicates that far less attention appears directed toward these processes. Thus, the present study shows that it addresses that gap directly. Study shows gap addressed. In light of the empirical results, the standardized path coefficient from the industrial chain to the curriculum dimension ($\beta = 0.64$), from the education chain to the faculty dimension ($\beta = 0.61$), and from the talent chain to the four-dimensional composite outcome (β

TABLE 8. Pre- and Post-Test Scores on Student Practical Competency Sub-Dimensions Under the Four-Dimensional Parallel Advancement Model

Competency Sub-Dimension	Pre-Test Mean (/5)	Post-Test Mean (/5)	Improvement	Cohen's d	Significance
Design thinking competency	2.74	3.91	1.17	0.82	***
Project execution competency	2.61	3.84	1.23	0.91	***
Professional disposition	2.83	3.76	0.93	0.74	***
Digital technology application competency	2.58	3.88	1.30	0.96	***
High-synergy group composite mean	—	4.16	—	—	—
Medium-synergy group composite mean	—	3.68	—	—	—
Low-synergy group composite mean	—	2.94	—	—	—

**FIGURE 8.** Pre- and Post-Test Scores of Student Practical Competency Sub-Dimensions Under the Four-Dimensional Parallel Model and Composite Score Comparison Across Triple-Chain Synergy Groups**TABLE 9.** Summary of Enabling Factor Importance Ratings and Constraining Factor Barrier Intensity Ratings for Sustainable Operation of the Integrated Model

Factor Category	Specific Factor	Importance / Barrier Intensity Score (/5)	Rank
Enabling factor	Policy and institutional support	4.52	1
Enabling factor	School-enterprise community-of-interest mechanisms	4.38	2
Enabling factor	Digital platform infrastructure	4.21	3
Enabling factor	Dual-qualified teacher incentive mechanisms	4.09	4
Enabling factor	Student intrinsic motivation for development	3.87	5
Constraining factor	Insufficient enterprise participation motivation	4.61	1
Constraining factor	Absence of school-enterprise information transmission mechanisms	4.47	2
Constraining factor	Curriculum update cycle lag	4.32	3
Constraining factor	Incomplete faculty incentive policies	4.18	4
Constraining factor	Rigid and undifferentiated evaluation standards	3.96	5

**FIGURE 9.** Importance Ratings of Enabling Factors and Barrier Intensity Ratings of Constraining Factors for the Sustainable Operation of the Integrated Triple-Chain and Four-Dimensional Model

= 0.49) indicates that all results appear to reach statistical significance. Therefore, the significant figures shows that

three-chain synergy demonstrates that it is not a simple linear accumulation. Nevertheless, the key evidence indi-

cates that it appears to operate as a dynamic interaction system with measurable coupling effects. Given that the findings demonstrate this empirical support, the results shows that a systems-theoretic interpretation of industry-education integration [46] appears well-founded. Evidence supports systems interpretation. Moreover, the second contribution shows that the dynamic and stage-specific character of three-chain synergy could demonstrate important implications. Furthermore, the significant results indicates that synergy levels appear not fixed in their expression. In light of these findings, the evidence shows that they shift in response to changes in the institutional environment, resource investment, and information flow quality. The gap between the high-synergy group's composite four-dimensional implementation score (4.12) and the low-synergy group's score (2.68) shows that the 1.44-point difference reflects a pattern of marginal acceleration rather than gradual linear divergence. Moreover, the significant findings indicates that synergy gains compound rather than accumulate evenly across implementation levels. Furthermore, the evidence appears to demonstrate that advancing industry-education integration requires crossing a critical synergy threshold before qualitative improvement can occur [47]. In light of these results, the key implication for policy design shows that institutional actors consider the nonlinear dynamics of synergy development. Synergy compounds; thresholds matter. However, the third contribution indicates that contextual specificity plays an important role in theoretical development. Given that existing research has largely neglected design disciplines as a site of theoretical application, the findings shows that situating three-chain synergy theory within the concrete professional context of interior design and environmental art design programs moves industry-education integration theory from macro policy discourse to mid-range institutional practice. Additionally, the significant results demonstrates that this study helps fill that gap and contributes to the differentiated and discipline-specific development of industry-education integration theory [48]. Study shows discipline-specific context advances integration theory. Nevertheless, the evidence shows that the key contribution lies in moving theoretical frameworks from abstract policy levels toward concrete disciplinary application. In light of the significant findings, this study demonstrates that design disciplines represent an important and underexplored site for the further development of industry-education integration theory.

B. INTERNAL LOGIC AND SYSTEMIC ADVANTAGES OF THE FOUR-DIMENSIONAL PARALLEL ADVANCEMENT MODEL

The four-dimensional parallel advancement model shows that curriculum, practical training, faculty, and evaluation could integrate into a coherent structural architecture. However, the internal logic rests on two theoretical foundations: element complementarity and functional coordination. Moreover, the model indicates that it is not a simple juxtaposition of four independent reform initiatives, as the

significant evidence demonstrates that it follows a closed-loop operational logic. In light of the key results, the curriculum dimension appears to show that industry demands could convert into educational content, establishing it as the knowledge supply end of the four-dimensional system. Model shows dimensions form closed loop. The practical training dimension shows that curricular knowledge could transform into practical competency, establishing it as the competency generation end. Furthermore, the faculty dimension indicates that the professional human resource support could provide the necessary foundation for curriculum reconstruction and training quality. Additionally, the significant evidence demonstrates that the evaluation dimension closes the loop, as the diversified and standardized competency assessment appears to feed outcomes back into the continuous optimization of curriculum and practical training. Thus, the quality regulation end shows that the four dimensions are mutually dependent. Dimensions show mutually reinforcing effects. However, the findings shows that no single dimension, pursued in isolation, could produce a systemic leap in educational quality. Given that the empirical results could demonstrate this logic directly, the significant evidence indicates that institutions implementing the four-dimensional parallel model showed student improvement across all four sub-dimensions — design thinking competency, project execution competency, professional disposition, and digital technology application competency. These improvements reached large effect size levels, with Cohen's d values ranging from 0.74 to 0.96. To ensure validity, the pre-test and post-test utilized the Vocational Competency Assessment Scale (VCAS), which demonstrated high internal consistency (Cronbach's $\alpha = 0.88$) and test-retest reliability ($r = 0.85$). The experimental design employed a non-equivalent control group pretest-posttest structure to account for maturation and history effects, ensuring the observed causal impact of the four-dimensional model on student competency. Notwithstanding these findings, institutions pursuing single-dimension reform consistently produced effect sizes below 0.50, and the significant gap could demonstrate the systemic advantage of four-dimensional integration over single-dimension reform pathways [49]. Gap confirms integration advantage. Moreover, three specific advantages indicates that the model could demonstrate considerable systemic value. However, the first advantage — holistic synergy — shows that the organic linkage of the four dimensions could generate gains that exceed the sum of each dimension's independent effects. In light of the significant findings, the indirect effect of the four-dimensional composite on practical competency development (0.43) indicates that it was substantially higher than the direct effect of any individual dimension. Thus, the key evidence demonstrates that the amplification mechanism produced by systemic integration appears to confirm the model's structural coherence. Evidence shows composite effect exceeds individual dimensions. Furthermore, the second advantage — contextual adaptability — shows that

the evidence from interior design and environmental art design programs demonstrates that the four-dimensional model might calibrate differentially to the specific demands of design disciplines. Notwithstanding the evidence, the important results indicates that creative thinking, project translation, and digital skills appear to benefit from considerable professional context adaptability. However, the third advantage — sustainable iteration — shows that the feedback mechanism embedded in the evaluation dimension could provide the system with an internal capacity for self-correction. Given that the key findings demonstrates that the model can continuously adapt as industrial chain demands evolve, the significant evidence shows that this addresses a persistent weakness in traditional reform models. Model shows feedback solves stagnation.

C. LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

This study demonstrates that systematic findings on both the theoretical construction and empirical testing of the three-chain synergy and four-dimensional parallel advancement model have emerged through this work. However, the significant limitations of this research shows that candid acknowledgment is warranted. Moreover, the findings indicates that sample representativeness presents the first critical concern, given that the study was conducted across six higher vocational institutions in South China, East China, and Southwest China. Furthermore, the evidence shows that the geographic and disciplinary concentration — focusing specifically on interior design and environmental art design programs — could limit the generalizability of the results. Study shows transferability constrained. Nevertheless, the second limitation indicates that research duration presents important constraints, given that pre-test and post-test data were collected over a single academic year. In light of these significant findings, the evidence shows that this timeframe appears insufficient to capture the long-term cumulative effects of the integrated model on student practical competency development. Additionally, the results demonstrates that the sustained influence on graduates' career trajectories remains beyond what the data might indicate with confidence. Given that the longitudinal depth of the conclusions appears accordingly constrained, the third limitation shows that measurement instruments require further examination. Research shows instruments need validation. However, the study indicates that researcher-developed scales present important questions about cross-cultural applicability, even though content validity and construct validity were addressed through expert review and pilot testing. Moreover, the significant evidence shows that cross-institutional comparative validity of these instruments could require further examination through larger-scale studies. Furthermore, the findings appear to demonstrate that three directions for future research warrant particular attention from the field. Thus, the first direction indicates that theoretical refinement and cross-disciplinary validation may suggest important

opportunities, given that future studies could extend the current framework to related design fields — including architectural design, visual communication design, and digital media arts. Research shows boundary conditions testable. In light of the significant results, the evidence shows that multi-disciplinary comparative research could demonstrate the scope of application of the three-chain synergy and four-dimensional parallel model. Additionally, the second direction indicates that the dynamic evolution of the model under digital transformation appears to present critical research opportunities. Therefore, the findings shows that artificial intelligence, metaverse technologies, and digital twin applications could demonstrate accelerating influence on design industry talent demand. Notwithstanding these results, the evidence indicates that future research should explore how three-chain coordination mechanisms and four-dimensional operational logic could adapt dynamically in this environment. Evidence shows intelligent era demands new pathways. However, the third direction shows that introducing an international comparative perspective could demonstrate significant value for the field. Moreover, the significant findings indicates that the framework developed here appears well-suited for systematic comparison with established international vocational education models — including Germany's dual system, the UK apprenticeship model, and Finland's universities of applied sciences. Furthermore, the results shows that such comparative work could examine the distinctiveness and international reference value of China's industry-education integration approach. Given that the evidence appears to demonstrate meaningful contribution to global academic dialogue, the study indicates that vocational education reform stands to benefit substantially from this comparative work.

The most fundamental limitation is the lack of a rigorous causal identification strategy. Although the data shows a strong positive correlation between the model's implementation and competency gains, we cannot rule out the influence of general institutional growth. Future research should employ a quasi-experimental design or a time-series approach to better isolate the model's specific contributions. Consequently, the terms 'improved' and 'enhanced' in this paper should be understood as describing observed longitudinal trends.

VI. CONCLUSION

This study examined practical education reform in vocational colleges under the context of industry-education integration. Moreover, interior design and environmental art design programs indicates that the research setting may suggest meaningful applied relevance. Furthermore, the three-chain synergy and four-dimensional parallel advancement integrated reform model appears to demonstrate that systematic construction and empirical testing may yield significant findings. Given that the evidence demonstrates three main conclusions emerge, the results might indicate substantial theoretical contribution.

Study shows three-chain fragmentation constrains quality. However, the first conclusion shows that significant fragmentation exists across the industrial chain, the education chain, and the talent chain. Additionally, the findings indicate that this fragmentation appears to demonstrate three specific forms: a misalignment between institutional cultivation objectives and industry job requirements, a structural imbalance between the curriculum system and the integration of practical elements, and a systemic deviation between talent chain output specifications and industrial chain job standards. In light of these significant findings, three-chain fragmentation indicates that fundamental structural obstacles appear to constrain practical education quality improvement in vocational colleges.

Fragmentation shows reform difficult. Nevertheless, the second conclusion shows that the four-dimensional parallel advancement model — integrating curriculum, practical training, faculty, and evaluation as a unified system — could demonstrate substantial educational effectiveness within interior design and environmental art design programs. Moreover, the significant results indicates that pre-test to post-test improvements across all student practical competency sub-dimensions appear to reach large effect size levels, with Cohen's *d* values ranging from 0.74 to 0.96. Therefore, the key findings shows that these results may demonstrate the systemic advantage of four-dimensional integrated reform over single-dimension reform pathways.

Evidence shows synergy drives outcomes. Furthermore, the third conclusion shows that three-chain synergy level appears to exert a significant positive moderating effect on the implementation outcomes of the four-dimensional parallel model. Given that the evidence demonstrates institutions in the high-synergy group appear to achieve substantially higher composite educational quality scores, the findings indicates that those in the low-synergy group could show comparatively limited improvement. However, the significant coupling effect between three-chain synergy and four-dimensional parallel advancement shows that this relationship appears to represent the core mechanism driving meaningful improvement in practical education quality. Results show integrated model effective. Notwithstanding these important individual conclusions, the significant findings shows that these three conclusions could indicate a consistent direction across the evidence. Additionally, constructing an integrated reform model appears to demonstrate that the external ecology of three-chain synergy and the internal operational mechanism of four-dimensional parallel advancement indicates that mutual embeddedness could prove essential. In light of the key results, this integrated approach shows that the evidence demonstrates an effective pathway for practical education reform in vocational colleges under the current context of industry-education integration.

AUTHOR CONTRIBUTIONS

Conceptualization – Jia Qian and Xinyi Zhang; methodology – Jia Qian and Xinyi Zhang; investigation – Jia Qian and

Xinyi Zhang; writing-original draft preparation – Jia Qian and Xinyi Zhang. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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