INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN PROGRESSIVE EDUCATION & DEVELOPMENT

OPEN ACCESS JOURNAL

Vol 15, Issue 2, (2026) E-ISSN: 2226-6348

Modeling Industry–Education Integrated Talent Cultivation in Higher Vocational Education: A Collaborative Innovation Framework Based on the Chengdu–Chongqing Twin-City Economic Circle

Li Wanli[1] & Normaliza Abd.Rahim[2]

[1]Faculty Of Arts, Communication & Education, Kuala Lumpur University of Science and Technology (KLUST), MALAYSIA, [2]Kuala Lumpur University of Science and Technology (KLUST)&INTI International University，MALAYSIA

Email: lwl0373@163.com, normaliza.abdrahim@newinti.edu.my

DOI Link: http://dx.doi.org/10.6007/IJARPED/v15-i2/28176

Published Online: 13 May 2026

Abstract

Industry-education integration stands as a core issue in vocational education reform in the new era and a vital driver for supporting high-quality regional economic development. However, current practices face a structural dilemma characterized by 'enthusiastic schools but lukewarm enterprises,' where institutional advantages fail to translate effectively into talent cultivation outcomes. This necessitates systematic exploration of its underlying mechanisms. This study, set within the Chengdu-Chongqing Economic Circle, aims to: (1) examine the impact mechanism of collaborative governance on digital integration; (2) analyze the pathway through which digital integration influences capability integration; and (3) discuss the effect of capability integration on talent adaptability. Employing quantitative research methods, this study sampled 150 participants—including faculty, administrators, and corporate personnel—from eight vocational colleges and their partner enterprises in the Chengdu-Chongqing region. Data were collected via a self-developed'Industry-Education Integration Collaborative Innovation Questionnaire,'analyzed using SPSS 27.0 and Mplus 8.3 for reliability/validity testing, correlation analysis, and structural equation modeling, grounded in collaborative governance theory. Results indicate that collaborative governance significantly and positively influences digital integration (β=.41, p<.001); digital integration significantly and positively influences capability integration (β=.48, p<.001); and capability integration significantly and positively influences talent adaptability (β=.62, p<.001). Model fit indices were satisfactory (CFI=.95, TLI=.93, RMSEA=.055). Future research may expand sample size and adopt longitudinal tracking designs to further validate causal mechanisms. This study provides theoretical foundations and practical references for deepening industry-education integration reforms.

Keywords: Industry-Education Integration, Collaborative Innovation, Future-Oriented Talent, Chengdu-Chongqing Region, Structural Equation Modeling

Introduction

Against the backdrop of coordinated regional development and the accelerated upgrading of industrial structures, how to achieve effective integration between the education system and the industrial system has become a key issue affecting high-quality economic development. In particular, amid rapid technological iteration and the deepening digital transformation of industries, traditional supply-oriented talent development models are increasingly unable to meet the industry's demand for versatile and adaptable professionals. Therefore, conducting systematic research on mechanisms for industry-education integration not only holds significant theoretical value but also directly impacts the quality of regional economic development and the efficiency of human resource allocation.

As a key strategic region, the Chengdu-Chongqing Metropolitan Area bears the important mission of driving economic growth in the western region and optimizing the regional development landscape. In this process, vocational education is entrusted with the dual functions of supporting industrial upgrading and promoting the optimization of the employment structure. However, in reality, there remains a widespread disconnect between educational supply and industrial demand, manifested in issues such as insufficient corporate participation, ineffective coordination mechanisms, and low resource allocation efficiency. These problems not only constrain the quality of talent cultivation but also hinder the sustained enhancement of regional innovation capacity. Consequently, there is a clear and urgent need to thoroughly examine the intrinsic operational logic and mechanisms of industry-education integration.

From a practical perspective, this study holds direct value for multiple stakeholders. For governments, it helps optimize policy design and collaborative governance mechanisms, enhancing the precision and effectiveness of institutional provision; for vocational colleges, it provides a basis for curriculum reform and innovation in talent development models; and for enterprises, it helps strengthen their involvement in talent development, thereby better aligning with industrial development needs. Additionally, from a regional development perspective, this study offers theoretical support for improving the coordination efficiency between industrial and educational chains, thereby promoting the rational flow and efficient allocation of innovation resources.

Based on this, this paper takes the Chengdu-Chongqing region as its research context, focusing on the issue of coordination mechanisms in industry-education integration, and systematically analyzes the pathways through which these mechanisms influence the quality and adaptability of talent cultivation. By constructing a multidimensional analytical framework and conducting empirical tests, the study aims to reveal the intrinsic connections among institutional arrangements, technological support, and capacity building, thereby providing theoretical explanations and practical references for advancing industry-education integration from a policy-driven approach toward mechanism optimization.

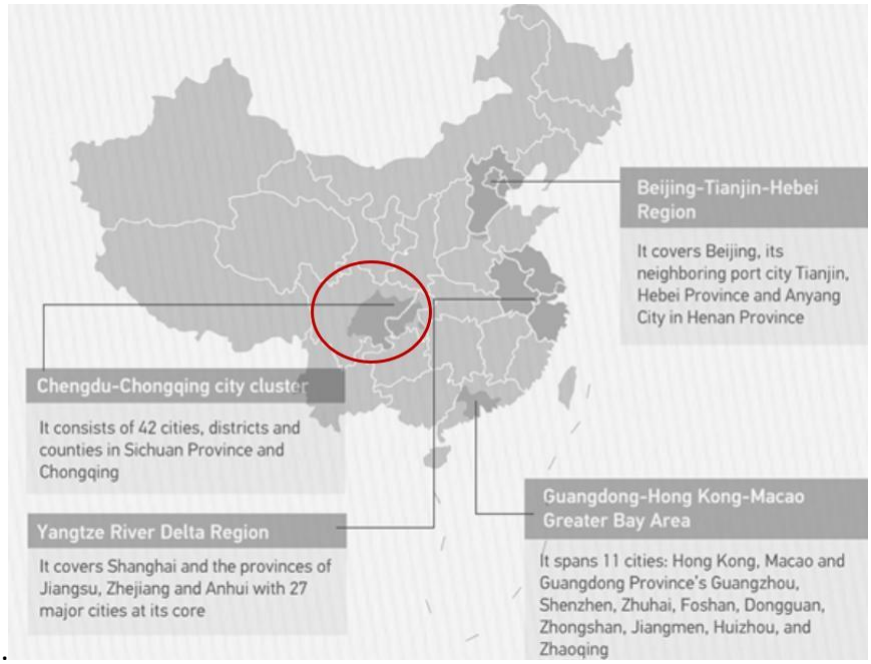

Figure 1. Schematic Diagram of the Strategic Layout of China's Four Major Urban Agglomerations
(Image Source: Compiled and drawn based on CGTN's report Decoding: China's Chengdu-Chongqing Twin-City Economic Circle and related planning materials)

Caption: This map illustrates the spatial distribution and strategic positioning of China's four national-level urban agglomerations, highlighting the key position of the Chengdu-Chongqing Twin-City Economic Circle in the regional coordinated development pattern. The official scope of the Beijing-Tianjin-Hebei coordinated development strategy includes Beijing, Tianjin, and Hebei Province. the spatial relationship shown in the map is only illustrative.

Literature Review

Collaborative Mechanisms for Industry-Education Integration: From Institutional Design to Governance Effectiveness

Industry–education integration is widely recognized as a core strategy for aligning education with industrial needs (Wei et al., 2024; Yang et al., 2024. Lin et al., 2026). Recent studies further highlight that governance mechanisms significantly influence collaboration effectiveness (Xu et al., 2026; Yang et al., 2026. Li, 2025).. Recent studies emphasize that effective collaboration between educational institutions and enterprises requires the establishment of institutionalized governance mechanisms to promote resource sharing, joint decision-making, and coordinated policy implementation (Wei et al., 2024; Yang et al., 2024; Liu & Zhang, 2023). Within the Sichuan-Chongqing region context, scholars argue that integrating industrial chains, educational chains, and talent chains can enhance regional innovation capacity and promote coordinated economic development (Ge & Shi, 2024; Li, 2025; Zhang, 2024). However, while these studies underscore the importance of institutional arrangements, most focus primarily on macro-level policy design and structural frameworks, lacking empirical analysis of how governance mechanisms operate in practice.

Other studies adopt critical perspectives to dissect implementation challenges in vocational education governance. Zhang (2024), drawing on institutional adaptation theory, argues that

Sichuan-Chongqing's vocational education system still lags significantly in responding to rapidly changing industrial demands. Similarly, Xu et al. (2026) found that governance structures within school-enterprise joint laboratories substantially influence collaborative innovation outcomes, demonstrating how institutional arrangements directly shape cooperative results. Earlier research by Guo (2022) also highlighted that fragmented governance structures and ambiguous benefit-sharing mechanisms often prevent regional vocational education systems from translating policy-level cooperation into sustained institutional practices. Compared to earlier discussions, recent studies have begun focusing on operational mechanisms, yet systematic empirical analysis across multi-stakeholder environments remains insufficient. Existing research reveals a persistent gap between institutional design and governance effectiveness, highlighting the urgent need for a more comprehensive analytical framework to elucidate how collaborative mechanisms influence the outcomes of industry-education integration.

Digital Transformation: Enabling Mechanisms and Structural Constraints in Industry-Education Integration

Digital transformation is widely recognized as a key driver for deepening the integration of industry, academia, and research. Recent studies emphasize that digital technologies such as smart education platforms, big data systems, and digital learning environments can facilitate knowledge transfer between educational institutions and enterprises and enhance the responsiveness of vocational education to industrial changes (Yang, 2026; Liu & Zhang, 2023; Yang et al., 2024). In particular, Yang (2026) demonstrates that digital intelligent teaching reforms can significantly improve teaching quality and enhance the alignment between vocational skills training and industrial technology development. Similarly, Liu & Zhang (2023) point out that digital platforms can promote the sharing of learning resources and industry knowledge among institutions, thereby supporting regional vocational education cooperation.

Despite these positive research findings, some studies emphasize that digital transformation alone cannot guarantee the success of industry-academia-research integration. Policy reports and empirical studies show that due to differences in digital infrastructure, technological capabilities, and institutional governance structures, the outcomes of digital transformation vary significantly across different regions and institutions (State Council, 2025; Wei et al., 2024; Zhang, 2024). For example, national policy documents emphasize the strategic role of national smart education platforms and the integration of artificial intelligence technology into the vocational training system (State Council, 2025). However, empirical research shows that enterprises often face numerous obstacles in participating in digital collaboration projects, such as concerns about data security, unclear profit distribution, and insufficient digital literacy among faculty and staff. Compared to previous research that primarily focused on the technological potential of digital tools, recent studies increasingly emphasize the importance of governance capabilities and institutional coordination in achieving effective digital integration. Therefore, digital transformation should not be viewed merely as a technological innovation, but rather as a systemic process embedded within a broader collaborative governance structure.

Future Work Trends and Paradigm Shift in Talent Development

The rapid transformation of the global labor market has spurred growing attention toward cultivating future-oriented competencies in vocational education. Scholars note that the traditional focus on developing job-specific technical skills is no longer sufficient to meet the demands of emerging industries characterized by digitalization, automation, and cross-disciplinary innovation (Duan, 2025; Deloitte, 2025; World Economic Forum, 2023). Duan (2025) proposes a composite competency model integrating engineering knowledge with business acumen, underscoring the importance of interdisciplinary skill development in modern vocational education. The World Economic Forum (2023) similarly emphasizes that future workforce development requires a broader competency framework encompassing digital literacy, analytical thinking, problem-solving abilities, and adaptability to technological change.

However, existing research predominantly focuses on specific dimensions of workforce transformation, with few studies constructing comprehensive frameworks for vocational talent development. For instance, Deloitte's Global Talent Trends Report indicates that under digital transformation, employee adaptability, lifelong learning capacity, and career resilience are increasingly vital (Deloitte, 2025). While these insights offer valuable perspectives on workforce development, they seldom explore how vocational education institutions should restructure curricula, teaching strategies, and industry-academia collaboration mechanisms to meet emerging competency demands. Early research also tends to analyze single dimensions like digital skills or innovation capabilities, without examining the interactions between different competencies within broader talent development ecosystems (Guo, 2022; Liu & Zhang, 2023). Consequently, existing literature lacks a systematic theoretical framework integrating governance mechanisms, digital transformation, and competency development within the context of industry-education integration. This study fills this gap by constructing a comprehensive analytical framework linking collaborative governance, digital integration, competency development, and talent adaptability, thereby providing a more holistic explanation of the intrinsic mechanisms of industry-education collaborative innovation.

Research Objectives

To explore the impact mechanism of collaborative governance on digital integration;
To analyze the path of digital integration on capability integration;
To discuss the impact of capability integration on talent adaptability.

Research Hypotheses

Based on collaborative governance theory (Ansell & Gash, 2008), resource dependence theory (Pfeffer & Salancik, 1978), and the aforementioned literature review, this study proposes the following research hypotheses:

H1: Collaborative governance significantly and positively influences digital integration**.** A robust collaborative governance mechanism provides institutional safeguards for the construction and operation of digital platforms, fostering deep cooperation between universities and enterprises in areas such as digital resource sharing and data standard alignment.

H2: Digital integration significantly and positively influences capability integration. The deep application of digital platforms breaks down information barriers between universities and

enterprises, systematically introducing cutting-edge industrial technologies, real-world project cases, and corporate expert resources into teaching processes. This drives curriculum content updates and pedagogical model transformations.

H3: Competency integration significantly and positively impacts talent adaptability. When students gain systematic professional competencies and meta-skills through industry-education integration, their overall capacity to navigate technological shifts and adapt to career transitions is substantially enhanced.

Methodology

Theoretical Framework

This study is grounded in Collaborative Governance Theory, which was systematically articulated by Ansell and Gash (2008). Collaborative governance refers to an institutional arrangement in which public agencies, private organizations, and other stakeholders collectively engage in consensus-oriented decision-making processes to address complex public issues. The theory highlights the critical roles of institutional design, trust-building, shared responsibility, and joint problem-solving among multiple actors.

In the context of industry–education integration, collaborative governance provides a robust analytical lens to explain how vocational institutions, enterprises, and government agencies coordinate resources, establish cooperative mechanisms, and jointly promote talent cultivation outcomes.

In addition, this study draws upon Resource Dependence Theory, originally proposed by Pfeffer and Salancik (1978), which posits that organizations depend on external actors for critical resources necessary for survival and development. To reduce uncertainty and secure essential resources, organizations tend to form interdependent and cooperative relationships. Within vocational education systems, educational institutions rely on enterprises for industrial knowledge, technological innovation, and practical training environments, while enterprises depend on vocational institutions for a stable supply of skilled human capital.

By integrating Collaborative Governance Theory and Resource Dependence Theory, this study constructs a multi-stage analytical framework. As illustrated in Figure 2, collaborative governance serves as the institutional foundation, facilitating digital integration through coordinated mechanisms and shared platforms. Digital integration, in turn, acts as a technological intermediary that enables the transformation of institutional collaboration into competency development. Subsequently, competency integration functions as the core mechanism driving the enhancement of talent adaptability.

Therefore, the framework conceptualizes a sequential pathway—Collaborative Governance → Digital Integration → Competency Integration → Talent Adaptability—revealing how governance structures, technological systems, and capability development jointly shape talent outcomes in industry–education integration.

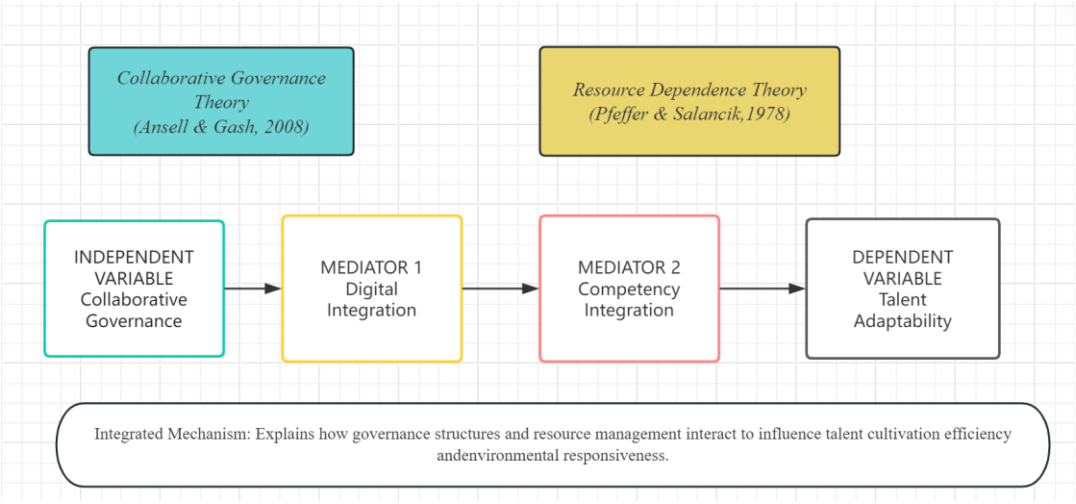

Figure 2. Theoretical Framework of Industry–Education Integrated Talent Cultivation

Note: The model illustrates the hypothesized relationships among four latent variables: Collaborative Governance, Digital Integration, Competency Integration, and Talent Adaptability. Arrows indicate the directional influence among constructs.

Research Design and Sample

This study employs a quantitative research design, utilizing the collaborative governance theory as its theoretical framework. A stratified random sampling method was used to select survey participants from eight higher vocational colleges and their partner enterprises in the Chengdu-Chongqing region. The sampling process comprised two stages: Stage 1: Participants were stratified by institution type (comprehensive, engineering-focused, finance-focused) and institutional level (National Double High Plan institutions, provincial-level demonstration institutions). Faculty and administrative staff were selected from the eight institutions. Stage 2: Enterprise personnel were stratified by enterprise size (large, medium, small) and selected from partner enterprise lists provided by each institution. A total of 150 questionnaires were distributed, with 150 valid responses collected, achieving a 100% valid response rate. The sample comprised 69 full-time faculty members (46.0%), 33 administrative staff (22.0%), and 48 enterprise personnel (32.0%); 81 males (54.0%) and 69 females (46.0%); 30 respondents with less than 3 years of work experience (20.0%), 47 with 3-5 years (31.3%), 42 with 6-10 years (28.0%), and 31 with over 10 years (20.7%).

Measurement Tools

Based on the theoretical framework and existing validated scales, this study developed the Industry-Education Integration Collaborative Innovation Questionnaire,comprising 16 items measuring four core variables: Collaborative Governance (4 items, e.g., Our institution and partner enterprises have clearly defined roles and responsibilities in our collaboration), Digital Integration (4 items, e.g.,Digital platforms are effectively utilized for resource sharing between our institution and enterprises), Competency Integration (4 items, e.g.,Curriculum systematically incorporates future core competencies such as digital literacy and critical thinking), and Talent Adaptability (4 items, e.g.,Graduates can rapidly adapt to technological transformations and job role changes). All items employed a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). The questionnaire was distributed via an online platform, with data collection occurring from December 2025 to January 2026.

Data Analysis and Theoretical Framework

Data analysis was conducted using SPSS 27.0 and Mplus 8.3. First, Cronbach's alpha was used to assess scale reliability, and confirmatory factor analysis was employed to evaluate scale validity. Subsequently, Pearson correlation analysis was used to preliminarily examine relationships among variables. Finally, structural equation modeling was employed to test research hypotheses, with model fit indices assessed using χ^2/df, CFI, TLI, RMSEA, and SRMR. This study adopts the collaborative governance theory (Ansell & Gash, 2008) as its theoretical framework. This theory emphasizes the processes of power distribution, interest coordination, and rule co-creation among multiple actors, providing a suitable theoretical perspective for understanding the collaborative innovation mechanism in industry-education integration.

Results and Discussion

Reliability and Validity Testing

The reliability analysis results showed that Cronbach's alpha coefficients for all variables ranged from .87 to .91（Table1）, all exceeding the acceptable threshold of .70, indicating that the scale possesses good internal consistency reliability. Composite reliability (CR) values ranged from .88 to .92, all exceeding the recommended threshold of .70, further confirming the reliability of the scale.

Table 1

Reliability Analysis Results for Each Variable (N=150)

Variable	Number of Items	Cronbach's α (α)	Composite Reliability (CR)	95% CI for α
Collaborative Governance	4	.88	.89	[.84, .91]
Digital Integration	4	.87	.88	[.83, .90]
Competency Integration	4	.91	.92	[.88, .93]
Talent Adaptability	4	.89	.90	[.86, .92]

Note: Confidence intervals were estimated based on the bootstrapping method (1000 resamples).

Regarding validity analysis, the KMO value was .86, and Bartlett's test of sphericity was significant ($p < .001$), indicating that the data were suitable for factor analysis(Table2). Confirmatory factor analysis results showed that the four-factor model yielded the best fit indices ($\chi^2/df = 2.02$, CFI = .95, TLI = .93, RMSEA = .055, SRMR = .045), significantly outperforming other competing models, indicating that the scale possesses good construct validity.

Table 2
Comparison of Confirmatory Factor Analysis Model Fit

Model	χ^2	df	χ^2/df	CFI	TLI	RMSEA	SRMR
Model 1 (One-factor)	856.45	104	8.24	.68	.64	.220	.142
Model 2 (Two-factor)	456.78	103	4.44	.81	.78	.152	.108
Model 3 (Three-factor)	298.56	101	2.96	.89	.87	.098	.072
Model 4 (Four-factor)	198.34	98	2.02	.95	.93	.055	.045
Recommended Criteria	-	-	**<3.00**	**>.90**	**>.90**	**<.08**	**<.08**

In terms of convergent and discriminant validity, the Average Variance Extracted (AVE) for each variable ranged from .58 to .69（Table3）, all exceeding the recommended threshold of .50 (Fornell & Larcker, 1981), indicating that the scale possesses good convergent validity. The square root of the AVE for each variable was greater than the correlation coefficients between that variable and other variables, indicating that the scale possesses good discriminant validity.

Table 3
Convergent and Discriminant Validity Analysis

Variable	AVE	1	2	3	4
1. Collaborative Governance	.62	.79			
2. Digital Integration	.58	.53	.76		
3. Competency Integration	.69	.48	.58	.83	
4. Talent Adaptability	.64	.45	.49	.68	.80

Note: Bold diagonal values are the square roots of AVE; lower triangle values are correlation coefficients between variables.

Common method bias was tested using Harman's single-factor test, where all items were subjected to unrotated principal component analysis. The results showed that the first factor explained 27.8% of the variance, below the critical threshold of 40% (Podsakoff et al., 2003). Additionally, the single-factor model in the confirmatory factor analysis showed poor fit (CFI = .68, RMSEA = .220), further indicating that common method bias was not severe and would not substantially affect the research conclusions.

Descriptive Statistics and Correlation Analysis

The means, standard deviations, and correlation coefficient matrix for each variable are presented in Table 4. In terms of means, scores for each variable ranged from 3.92 to 4.21, indicating that the overall development level of industry-education integration in higher vocational institutions in the Chengdu-Chongqing region is relatively high, although structural differences exist across dimensions. Among them, Collaborative Governance scored the highest (M = 4.21, SD = 0.62), while Digital Integration scored relatively low (M = 3.92, SD = 0.68), which aligns with the phenomenon of institutions first, technology lagging observed in qualitative research.

Regarding correlation analysis results, all variables showed significant positive correlations ($p < .001$), with correlation coefficients ranging from .62 to .68, providing preliminary support for subsequent hypothesis testing.

Table 4
Descriptive Statistics and Correlation Matrix (N=150)

Variable	M	SD	Skewness	Kurtosis	1	2	3	4
1. Collaborative Governance	4.21	0.62	-0.45	0.32	—			
2. Digital Integration	3.92	0.68	-0.28	0.15	.53***	—		
3. Competency Integration	4.05	0.65	-0.36	0.21	.48***	.58***	—	
4. Talent Adaptability	4.12	0.63	-0.41	0.28	.45***	.49***	.68***	—

Note: **p < .001; the absolute values of skewness and kurtosis for all variables are less than 1, indicating that the data are approximately normally distributed and suitable for parametric testing.

The Impact of Collaborative Governance on Digital Convergence

Structural equation modeling analysis shows (Table5)that collaborative governance has a significant positive impact on digital convergence (β=.41, p<.001), with H1 supported. This finding indicates that a sound collaborative governance mechanism can provide institutional guarantees for the construction and operation of digital platforms, promoting in-depth cooperation between universities and enterprises in areas such as digital resource sharing and data standard alignment. This result echoes Hao's (2023) research conclusions on the policy-mechanism collaborative path, further confirming the fundamental role of institutional design in technology empowerment. Wu (2024), using field theory, points out that the difficulty for enterprises to obtain equitable returns under existing institutional arrangements is a key reason for insufficient participation motivation. This study's finding of the positive impact of collaborative governance on digital convergence reveals that institutional optimization may be an effective path to overcome this dilemma.

This finding is further supported by recent empirical studies. Yang et al. (2026) demonstrated that digital transformation significantly enhances institutional coordination efficiency, while Lin et al. (2026) confirmed that industry–education integration mechanisms play a crucial role in improving collaborative governance effectiveness in vocational education systems.Simultaneously, this study's findings are consistent with Yang's (2026) view that digital transformation requires institutional support, emphasizing that digital convergence is not simply a technical issue, but a systemic issue deeply embedded in the governance structure. The Impact of Digital Convergence on Capability Integration. The results show that digital convergence has a significant positive impact on capability integration (β=.48, p<.001), with H2 supported. This finding reveals the key role of digital technology in industry-education integration: it is not only a teaching tool but also a technological bridge connecting institutional design and capability cultivation. Wang (2025) found that curriculum content updates lag behind industrial technological progress; this study finds that digital convergence

can effectively promote capability integration, providing a feasible path to overcome this dilemma. Yang (2026) demonstrated the potential of digital technology in improving teaching quality and skill matching through a case study of digital teaching reform; this study further confirms that the deep application of digital platforms can systematically introduce cutting-edge industry technologies, real project cases, and enterprise expert resources into the teaching process, promoting curriculum content updates and teaching model changes. This result is consistent with recent findings by Yang et al. (2026), who emphasized the coupling relationship between digital technology innovation and productivity development, indicating that digital integration serves as a critical intermediary mechanism in transforming institutional collaboration into competency development outcomes.Chen (2024) pointed out the restrictive effect of the evaluation system on digital teaching innovation; this study found a significant impact of digital convergence on capability integration, suggesting that the evaluation system should be reformed in the future to fully leverage the enabling effect of digital technology. The Impact of Competency Integration on Talent Adaptability

The results show that competency integration has a significant positive impact on talent adaptability (β=.62, p<.001), supporting H3. This finding is one of the most important conclusions of this study, revealing the core position of competency development in the educational function of industry-education integration. Duan (2025) proposed a composite competency model that emphasizes the integration of business and engineering competencies. This study confirms that systematic competency integration can significantly improve students' comprehensive ability to cope with technological changes and adapt to career transitions. Deloitte's (2025)Global Talent Trends 2026 points out that vocational education is facing a paradigm shift from skills transmission to career development support. This study found a strong effect of competency integration on talent adaptability, providing empirical support for this paradigm shift. Peng et al. (2025)'s study on the organizational density of industry-education integration focused on the effectiveness at the institutional level. This study delves into the competency development level, revealing the micro-mechanism of the educational function of industry-education integration. Sun (2025)'s research on modern apprenticeship emphasizes the importance of the benefit distribution mechanism. This study finds that capability integration is the core hub connecting the process of industry-education integration with talent output, enriching the perspective of existing research.Similarly, Xu et al. (2026) highlighted that competency development plays a mediating role in transforming institutional collaboration into tangible talent outcomes, further supporting the robustness of the findings in this study.

Table 5
Path Coefficient Test Results of the Structural Equation Model

Hypothesis	Path	Standardized Coefficient (β)	Standard Error (SE)	Critical Ratio (CR)	p-value	Test Result
H1	Collaborative Governance → Digital Integration	.41	.07	5.86	<.001	Supported
H2	Digital Integration → Competency Integration	.48	.06	8.00	<.001	Supported
H3	Competency Integration → Talent Adaptability	.62	.05	12.40	<.001	Supported

Structural Equation Model Testing
To test the research hypotheses and theoretical model(Figure1), this study used Mplus 8.3 to construct a structural equation model. The model fit indices are as follows: $\chi^2/df=2.02$, CFI=0.95, TLI=0.93, RMSEA=0.055, SRMR=0.045. All fit indices meet or exceed the recommended standards (Hu & Bentler, 1999), indicating that the model fits the data well.These findings are consistent with recent structural equation modeling studies in vocational education contexts (Xu et al., 2026), which also confirm the stability and explanatory power of multi-stage integration models.

Figure 1:Path Diagram of the Structural Equation Model
Note: $p < .001$; values in the figure are standardized path coefficients.

Effect Size Analysis
To further assess the practical significance of each path effect, this study calculated the effect size (f^2) for each path. According to Cohen's (1988) criteria, $f^2 \geq 0.02$ indicates a small effect, $f^2 \geq 0.15$ indicates a medium effect, and $f^2 \geq 0.35$ indicates a large effect(Table6).

Table 6
Path Effect Size Analysis

Path	R^2 included	R^2 excluded	f^2	Effect Size Rating
Collaborative Governance → Digital Integration	.28	.16	0.17	Medium Effect
Digital Integration → Competency Integration	.34	.20	0.21	Medium Effect
Competency Integration → Talent Adaptability	**.46**	**.28**	**0.33**	**Approaching Large Effect**

The results indicate that the effect size of competency integration on talent adaptability approaches a large effect (f^2=0.33), further highlighting the central role of competency development in the educational functions of industry-education integration.This result aligns with Lin et al. (2026), who emphasized that competency-oriented training models are essential for improving the adaptability and long-term development potential of vocational education graduates.

Multi-group Analysis: Perceptual Differences Across Roles
To explore perceptual differences among different stakeholder groups regarding the collaborative innovation mechanism in industry-education integration, this study conducted a multi-group analysis using role (faculty, administrators, industry personnel) as the grouping variable（Table7）. Results indicate that the model exhibits good fit across all three groups (Faculty group: CFI=.94, RMSEA=.058; Administrative group: CFI=.93, RMSEA=.060; Industry group: CFI=.92, RMSEA=.062), demonstrating cross-group stability.

Path	Teacher Group (n=69)	Administrator Group (n=33)	Enterprise Group (n=48)	Between-group Difference Test (χ^2 difference)
Collaborative Governance → Digital Integration	.44***	.40***	.35***	4.56*
Digital Integration → Competency Integration	.49***	.48***	.46***	1.34
Competency Integration → Talent Adaptability	.65***	.61***	.57***	4.12*

Table 7：Multi-group Analysis: Comparison of Path Coefficients Across Roles
Note: p < .05, **p < .001; between-group difference tests were conducted using the χ^2 difference between constrained and unconstrained models.

Cross-group comparison of path coefficients revealed that: on the path of Collaborative Governance → Digital Integration, the path coefficient for the enterprise group (β = .35) was significantly lower than that for the teacher group (β = .44), indicating that enterprises have

a lower evaluation of the empowering effect of current collaborative governance mechanisms on digital integration. On the path of Competency Integration → Talent Adaptability, the path coefficient for the enterprise group (β = .57) was significantly lower than that for the teacher group (β = .65), indicating that enterprises hold a more cautious view regarding the effectiveness of current competency development in enhancing talent adaptability. This finding is highly consistent with the phenomenon of 'enthusiastic schools, lukewarm enterprises' observed in qualitative research, further confirming the problem of insufficient endogenous motivation for enterprise participation.This observation is consistent with recent studies (Yang et al., 2026), which suggest that mismatches in benefit distribution and institutional arrangements remain key barriers to enterprise engagement in industry–education integration.

Summary of Results

The findings of this study confirm that collaborative governance, digital integration, and competency integration constitute a sequential mechanism influencing talent adaptability in higher vocational education. Specifically, collaborative governance significantly promotes digital integration (β = .41, $p < .001$), which subsequently enhances competency integration (β = .48, $p < .001$), ultimately improving talent adaptability (β = .62, $p < .001$). These findings are consistent with previous studies emphasizing the importance of institutional coordination and digital transformation in vocational education reform. Wei et al. (2024) and Yang et al. (2024) argued that effective cooperation between educational institutions and enterprises requires governance structures that enable resource sharing and policy coordination. Similarly, Liu and Zhang (2023) highlighted that digital platforms facilitate the integration of industrial knowledge into educational processes. The present study provides empirical support for these arguments by demonstrating that digital integration acts as a key bridge connecting governance structures with competency development in vocational education systems.

From a theoretical perspective, the results further validate the explanatory power of collaborative governance theory and resource dependence theory in the context of industry–education integration. According to collaborative governance theory (Ansell & Gash, 2008), effective collaboration among multiple stakeholders requires institutional arrangements that enable joint decision-making, trust building, and shared accountability. The significant relationship between collaborative governance and digital integration found in this study suggests that institutional coordination mechanisms play a fundamental role in enabling technological collaboration between universities and enterprises. Furthermore, resource dependence theory (Pfeffer & Salancik, 1978) explains that organizations seek cooperative relationships to obtain critical external resources. In vocational education, institutions depend on enterprises for industrial knowledge and technological updates, while enterprises rely on educational institutions to supply skilled labor. The positive influence of competency integration on talent adaptability reflects how these resource exchanges contribute to the development of workforce capabilities aligned with industrial transformation.

The empirical findings also provide strong support for the research hypotheses proposed in this study. Hypothesis 1 predicted that collaborative governance would positively influence digital integration, which was confirmed by the significant path coefficient obtained in the structural equation model. Hypothesis 2 proposed that digital integration would positively

influence competency integration, indicating that digital technologies can facilitate curriculum innovation and industry knowledge transfer. Hypothesis 3 suggested that competency integration would enhance talent adaptability, reflecting the capacity of graduates to respond to technological change and evolving labor market demands. All three hypotheses were supported by the empirical results, confirming the validity of the proposed conceptual model. These findings demonstrate that industry–education integration functions through a multi-stage mechanism in which governance structures, technological systems, and competency development interact to improve the adaptability of vocational education graduates.

Conclusion

This study, using the Chengdu-Chongqing Twin-City Economic Circle as its research context, constructs and empirically tests a three-dimensional model of collaborative innovation in industry-education integration. The findings offer valuable insights for policymakers, vocational school administrators, corporate partners, and vocational education researchers. For policymakers, this study reveals the promoting effect of collaborative governance on digital integration, suggesting strengthening the leading role of enterprises in policy design and establishing a governance mechanism based on shared benefits and risks. For vocational school administrators, this study confirms the crucial role of digital integration in capability consolidation, recommending increased investment in digital platform construction and promoting the deep integration of digital technology into the teaching process. For corporate partners, this study reveals the strong effect of capability consolidation on talent adaptability, suggesting active participation in curriculum development and the entire talent cultivation process to jointly cultivate high-quality talent adapted to future industry needs. For vocational education researchers, this study provides a testable theoretical framework, laying the foundation for subsequent research. The findings of this study indicate that deepening the integration of industry and education must transcend "project thinking" and "instrumental rationality" and move towards systematic collaborative innovation. Only when the three dimensions of system, technology, and capability evolve in synergy and empower each other can the integration of industry and education truly become an institutional force supporting high-quality regional economic development and the cultivation of future talents.

Author Biography

Li wanli is a Doctor Of Philosophy In Education from the Faculty of Arts, Communication and Education, Kuala Lumpur University of science and technology(Formerly known as Infrastructure University Kuala Lumpur). She is currently working in Chongqing Business Vocational College. She is mainly engaged in research on higher vocational education in China. Her PhD supervisor is Prof. Dr. Normaliza Abd Rahim.. Email:lwl0373@163.com , 242924790@s.klust.edu.my

Normaliza Abd.Rahim is a Professor Dr at INTI International University, Malaysia. Her expertise is in the field of Teaching and Learning, Education and Media and Communication to which is related to Communication Technology, Educational Technology, Media and Technology, social media, New Media, Multimedia in Education, Multimedia in Learning, Discourse Studies etc. She has published more than 200 articles in journals, chapter in books, proceedings, monographs etc. She has also published 11 academic books and more than 100

copyrights for books, animations, music scores, music lyrics and scripts for animations.
Email:normaliza.abdrahim@newinti.edu.my

References

Chongqing Municipal Education Commission. (2024, December 26). Chongqing Industry & Trade Polytechnic strengthens dual wings to deepen industry–education integration and support high-quality development of advanced manufacturing. https://jw.cq.gov.cn

Chongqing Municipal Education Commission. (2025, June 16). Yangtze Normal University promotes deep industry–education integration through the integration of four industries and four chains. https://jw.cq.gov.cn

Deloitte. (2025). Global human capital trends 2025: Navigating the future of work. Deloitte Insights.

Duan, X. (2025). Driving mechanisms and competency models for integrated industrial–engineering talent cultivation in inland open economic centers. iEducation, 1(3), 30–45.

Ge, J., & Shi, Y. H. (2024). Collaborative development pathways of higher vocational education under the construction of the Chengdu–Chongqing dual-city economic circle. Modern Vocational Education, 381, 7–10.

Guo, C. S. (2022). Scientific planning to build a regional highland of vocational education. Sichuan Political Consultative Conference Daily.

Li, T., Wang, J. C., & Wen, X. B. (2026). Reform of intelligent manufacturing talent cultivation model under the background of industry–education integration: A case study of Fujian Province. College and Job, 15, 392.

Li, Z. X. (2025). Construction pathways of industry–education integration communities in higher vocational colleges under the “Four Zones and One Highland” strategy. Journal of Hubei Open Vocational College, 38(10), 45–52.

Liu, B. M., & Zhang, Y. (2023). Regional collaborative development of digital skills in vocational education: Evidence from the Chengdu–Chongqing region. Vocational Education Forum, 38(7), 50–56.

Ministry of Education of the People’s Republic of China. (2024). Deepening educational collaboration between Sichuan Province and Chongqing Municipality to serve major national strategies (Ministry of Education Bulletin No. 31 [2024]). Ministry of Education.

National Leading Group for Employment Promotion and Labor Protection. (2025). Guiding opinions on launching large-scale vocational skills upgrading training programs (Document No. 4 [2025]). State Council.

Wei, J. F., Tang, L. B., & Wang, Y. R. (2024). A realistic review and breakthrough paths for collaborative enhancement of vocational education in the Chengdu–Chongqing dual-city economic circle. Education and Teaching Research, 38(3), 96–106.

World Economic Forum. (2023). The future of jobs report 2023. World Economic Forum.

Xu, L. Z., Deng, R. C., Liu, J. H., Chen, L. B., & Yang, Y. (2026). Governance structures and institutional innovation of university–enterprise joint laboratories: A perspective from new engineering talent cultivation. Service Science and Management, 15, 157–164.

Yang, Q. (2026). Reform and practice of application-oriented talent cultivation in mechanical majors driven by digital intelligence through deep university–enterprise integration. Advances in Education, 16, 707–715.

Yang, R. S., Jiao, S. Q., & Luo, X. (2024). Constructing a new ecosystem for application-oriented talent cultivation in industry-specific universities through industry–education integration. China Higher Education, 2, 33–36.

Yang, S. Y., Yang, Y. F., Zhang, M., Wu, H. N., & Luo, S. W. (2026). Spatiotemporal pattern and interaction response of coupling coordination between digital technology innovation and new quality productivity development. Journal of Neijiang Normal University, 41(2), 79–92.

Zhang, C. P. (2024). Adaptability of higher vocational education in the Chengdu–Chongqing dual-city economic circle. Vocational Education, 23(409), 20–25.