The Impact of Structured College-Industry Collaboration Programs on Graduate Employability: A Study of Four Key Collaboration Types in Jinan, Shandong's Higher Vocational Institutions

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ABSTRACT:

College–industry collaboration is widely promoted as a strategy for enhancing graduate employability in vocational education. However, empirical evidence remains mixed, partly because collaboration is often treated as a single, undifferentiated construct. This study examines how four distinct forms of college–industry collaboration, namely curriculum development collaboration, internship collaboration, research project collaboration, and knowledge exchange collaboration, are associated with graduate employability in higher vocational institutions in Shandong Province. Stratified random sampling was used to collect data from 1,124 senior students, recent graduates, and collaborative faculty from three major vocational institutions, including senior students, recent graduates, and faculty members involved in collaborative activities. The measures captured the four collaboration dimensions and graduate employability as a multidimensional construct encompassing technical competence, job readiness, adaptability, and career confidence. Pearson's correlation and multiple regression analyses were conducted in SPSS to test the hypothesized relationships. The results showed that all four types of collaboration were positively linked to graduate employability and together accounted for a large part of the differences in employability outcomes. Regression findings revealed that research project collaboration was the strongest predictor of graduate employability, followed by knowledge exchange collaboration and internship collaboration. In contrast, curriculum development collaboration, although significant, exhibited the weakest unique effect.

Keywords: College-Industry Collaboration; Vocational Education; Graduate Employability; China; Education Policy

1. Introduction

College–industry collaboration (CIC) is widely promoted as a strategic mechanism to improve graduate employability, particularly in vocational education, where labour market outcomes often determine programmer legitimacy. In China, accelerated industrial upgrading and the diffusion of new technologies have heightened

concerns about skills mismatch, short employment tenures, and limited pathways for sustained career development among vocational graduates (OECD, 2021; Ministry of Education [MOE], 2020). Although collaboration between colleges

and industry is frequently positioned as a solution, policy endorsement does not automatically translate into effective implementation, and empirical evidence remains uneven regarding which forms of collaboration matter most and why (Zhang & Yang, 2021).

A persistent problem in the literature is that CIC is commonly treated as a unitary construct rather than a set of differentiated practices. Many studies discuss CIC broadly without disaggregating distinct collaboration forms such as curriculum co-development, structured internships, joint research projects, and systematic knowledge exchange. This limits the explanatory precision because each collaboration type plausibly operates through distinct mechanisms and produces distinct employability benefits (Bridgstock, 2009; Toner, 2011). In parallel, employability is often operationalised narrowly as job access or employment rate, despite research emphasising employability as a multidimensional capacity that supports securing, performing, and sustaining suitable work (Yorke, 2006; OECD, 2021). These conceptual limitations create a gap in understanding the differentiated effects of specific CIC practices on vocational graduate employability in rapidly industrializing contexts.

This study addresses these gaps by examining CIC within higher vocational institutions in Jinan, Shandong Province, an industrial city that provides a meaningful setting for understanding education–industry alignment under structural economic transition. The study conceptualises CIC as comprising four structured forms and evaluates their distinct contributions to a single employability outcome. Accordingly, the study is guided by the following objective: to examine how four forms of CIC influence vocational graduates' employability in Jinan, Shandong Province and to identify which collaboration form(s) exhibit stronger explanatory power in this context.

2. Underpinning Theories

This study is theoretically anchored in four complementary perspectives that explain why and how structured CIC influences employability outcomes.

Employability Theory conceptualises employability as a multidimensional capacity that includes disciplinary competence, transferable skills, and personal attributes that enable individuals to obtain and sustain suitable work amid changing labour market conditions (Yorke, 2006). From this viewpoint, CIC contributes to employability by embedding learning in authentic work contexts and strengthening the translation of educational experiences into work-ready capability.

Human Capital Theory explains education and training as investments that increase productivity and enhance economic returns at both individual and societal levels (Becker, 1993). In vocational education, CIC serves as an alignment mechanism that can enhance the relevance and market value of acquired human capital by ensuring that curricula, training exposure, and assessment align with industry needs.

Knowledge Transfer Theory focuses on how institutions and industries exchange knowledge, skills, and technologies to produce applied value, innovation, and practice-ready competence (O'Connor, 2022). Within higher vocational education, knowledge transfer is operationalised through joint research projects, employer-led training, and structured knowledge exchange channels that enable curriculum updating and skill modernisation.

Collaborative Learning Theory, grounded in social constructivism, proposes that learning is enhanced through interaction, shared problem solving, and guided participation with more capable peers or mentors (Vygotsky, 1978). In CIC settings, collaborative learning occurs when students engage with industry mentors and lecturers on real tasks, thereby developing communication, teamwork, adaptability, and professional identity, which are frequently treated as core elements of employability.

These theories support a model in which

differentiated CIC practices constitute distinct inputs into employability development, with varying effectiveness depending on how they structure authentic learning, human capital accumulation, and knowledge exchange.

3. Literature Review

Evidence broadly supports the claim that stronger college–industry linkages are associated with improved vocational graduate outcomes, including smoother transitions and higher employability (Wang & Liu, 2023). However, a more recent line of argument suggests that employability benefits depend on whether collaboration is implemented as an integrated set of practices rather than as isolated initiatives (Zhou & Wu, 2024). This implies the need to distinguish collaboration types and compare their relative contributions.

Curriculum development through co-design and updating with industry stakeholders is commonly identified as foundational because it improves alignment between training content and workplace requirements. Studies in vocational contexts suggest that such alignment can reduce mismatch and strengthen job readiness, particularly in sectors experiencing technological change (Li et al., 2024).

Internships constitute a direct mechanism for work-integrated learning that strengthens employability through experiential exposure, occupational socialization, and development of practical competence. Where internships are structured, supervised, and assessed, they are more likely to yield transferable skills and clearer employment pathways (Chen & Wu, 2023).

Research projects linked to industry have been increasingly discussed as mechanisms for cultivating innovation, applied problem-solving, and higher-order competence, particularly in technology-oriented vocational tracks. Evidence from collaborative projects suggests enhanced problem-solving capacity and improved employment prospects when industry mentors actively participate, and projects align with curriculum requirements

(Chen & Liu, 2023; Li & Wang, 2023). The emergence of digitally supported coordination platforms has further improved project management and knowledge sharing in joint

initiatives (Zhou & Li, 2024).

Knowledge exchange practices, such as employer-led seminars, staff exchanges, and competency mapping, support the continuous updating of institutional capacity and student readiness. Longitudinal research indicates that graduates with greater exposure to applied collaboration experience demonstrate improved career progression and involvement in innovation-oriented work (Liu et al., 2024).

Despite these advancements, three gaps remain salient. First, studies still often aggregate CIC, limiting insight into which collaboration form matters most. Second, regional evidence from China's vocational sector, especially at the city level in industrial centres such as Jinan, is comparatively limited (Zhang & Yang, 2021). Third, employability measurement frequently priorities short-term job access over broader capacity-based outcomes, thereby weakening its theoretical alignment with established employability conceptualizations (Yorke, 2006; OECD, 2021). These gaps justify a typology-driven design that examines differentiated CIC practices as independent predictors of a single employability outcome in a defined regional context. Therefore, we hypothesized that:

H1: Curriculum development collaboration is positively associated with graduate employability among higher vocational graduates in Jinan, Shandong Province.

H2: Internship collaboration is positively associated with graduate employability among higher vocational graduates in Jinan, Shandong Province.

H3: Research project collaboration is positively associated with graduate employability among higher vocational graduates in Jinan, Shandong Province.

H4: Knowledge exchange collaboration is positively associated with graduate employability among higher vocational graduates in Jinan, Shandong Province.

This study is significant in three ways. Theoretically, it advances a more precise

understanding of CIC by modelling collaboration as differentiated practices rather than a single aggregated construct, aligning measurement with Employability Theory and knowledge exchange perspectives (Atkins et al., 2011; Yorke, 2006). Empirically, it provides context-specific evidence from Jinan, an industrial city that can illuminate how vocational education collaborations function under rapid economic transition (MOE, 2020; OECD, 2021). In practice, it offers actionable implications for policymakers and institutional leaders by identifying which forms of collaboration should be prioritised, strengthened, or redesigned to generate substantive employability gains rather than symbolic compliance (Zhang & Yang, 2021).

4. Methodology

4.1 Research Design

This study employed a cross-sectional quantitative research design to examine the relationship between differentiated forms of CIC and graduate employability among higher vocational students and recent graduates in Jinan, Shandong Province. Data were collected at a single point in time using a structured questionnaire, enabling analysis of associations between variables without manipulation or temporal sequencing. A cross-sectional approach is appropriate for this study as it enables efficient examination of multiple collaboration practices and their differential effects on employability outcomes within a defined institutional and regional context.

4.2 Population and Sample

The target population comprised individuals directly involved in structured CIC initiatives within higher vocational colleges (HVCs) in Jinan. Specifically, the population included:

1. Second- and third-year vocational students enrolled in HVCs in Jinan.
2. Recent vocational graduates who had completed their programmes within the previous three years.
3. Faculty members involved in the implementation of CIC activities.

To ensure clear population boundaries, only institutions with formalized CIC arrangements were included. These arrangements consisted of signed memoranda of understanding, curriculum co-development, structured internship programmes, collaborative research activities, and organised knowledge exchange initiatives.

According to data from the Jinan Education Bureau (2023), higher vocational institutions in Jinan collectively enrol approximately 120,000 students and employ about 6,000 faculty members. For feasibility and representativeness, three major vocational institutions were purposively selected: Jinan Engineering Vocational and Technical College, Jinan Vocational College, and Shandong Institute of Commerce and Technology. These institutions were selected because they enrol large student populations, offer programmes aligned with key industrial sectors in Jinan, and demonstrate sustained engagement in CIC practices.

Eligible student participants included second- and third-year students, as well as graduates who had completed their studies within the previous three years. These groups were considered to have sufficient exposure to CIC initiatives to provide informed responses regarding collaboration experiences and employability outcomes. First-year students were excluded due to limited involvement in CIC activities. Faculty members teaching both theoretical and practical modules linked to CIC were also included to capture institutional perspectives on implementation.

The estimated population across the selected institutions was approximately 84,363 individuals. A total of 1,124 respondents were selected using stratified random sampling, ensuring proportional representation of students, graduates, and faculty members. Sample size adequacy was determined using Cochran's formula with finite population correction, based on a 95 per cent confidence level ($Z = 1.96$), a margin of error of 5 per cent ($e = 0.05$), and maximum variance ($p = 0.50$). The initial estimated sample size was 384.16 and was adjusted for each stratum using finite population correction to ensure statistical precision and representativeness.

4.3 Research Instrument

The structured questionnaire was researcher-developed and conceptually adapted from established theories and prior empirical studies on college–industry collaboration and graduate employability, rather than adopted from a single standardized instrument. It was designed to measure both the independent and dependent variables as specified in the conceptual framework, with clear alignment to Employability Theory, Human Capital Theory, and Knowledge Transfer Theory.

The questionnaire comprised six sections. Part 1 captured demographic information (5 items). Parts 2 to 5 measured the four differentiated forms of college–industry collaboration (CIC): curriculum development (6 items), internship programs (6 items), research projects (6 items), and knowledge exchange (6 items). Part 6 measured graduate employability using 12 items covering skills, knowledge, competencies, and attributes.

All items were measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The Likert scale was selected due to its simplicity, robustness, and suitability for capturing the intensity of respondents' perceptions and experiences. Sample items included statements such as "The courses I took included modules co-designed with industry partners," "I was involved in research or innovation projects with real-world applications," "My internship responsibilities aligned with my field of study," and "I received mentoring or lectures from industry professionals."

4.4 Data Collection Procedure

Data were collected through self-administered questionnaires distributed to eligible participants across the three selected vocational institutions. Participation was voluntary, and respondents were informed of the study's purpose, confidentiality assurances, and their right to withdraw at any time. Completed questionnaires were screened for completeness before data entry and analysis.

4.5 Data Analysis

Quantitative data were analysed using SPSS version 28. Data screening procedures included checks for missing values, outliers, and response consistency. Descriptive statistics, including frequencies, means, and standard deviations, were used to summarize participant characteristics and levels of exposure to CIC activities.

Inferential analyses were conducted to test the study hypotheses. Multiple regression analysis was used to examine the effects of the four CIC dimensions on graduate employability, while controlling for programme type and year of graduation. Analysis of variance (ANOVA) was employed to assess differences in employability outcomes across collaboration types where appropriate. Statistical significance was evaluated at the 0.05 level.

5. Results

This section presents the results of the quantitative data analysis examining the relationship between differentiated forms of college–industry collaboration (CIC) and graduate employability among higher vocational students and recent graduates in Jinan, Shandong Province. The results are organised into four subsections: demographic characteristics, descriptive statistics, correlation analysis, and hypothesis testing using multiple regression analysis.

5.1 Demographic Characteristics of Participants

Table 1 presents the demographic profile of the 1,124 respondents who participated in the study. The sample was evenly distributed across age groups, with approximately one-third of participants aged 18–22, 23–26, and 27–30, indicating balanced representation of early- and later-stage vocational cohorts. Gender distribution was similarly balanced, with comparable proportions of female, male, and respondents who preferred not to disclose their gender. Participants were drawn almost equally from private and public vocational institutions, suggesting institutional diversity in the sample. Representation across fields of study was broad, with engineering and technology comprising the largest group, followed by agriculture and environmental studies, education, health and medicine, computer science and IT, business and management, and arts and

design. Graduation cohorts from 2025 to 2028 were also evenly represented.

Table 1. Demographic characteristics of participants (N = 1,124)

Variable	Category	Frequency	Percentage (%)
Age	18–22 years	372	33.1
	23–26 years	376	33.5
	27–30 years	376	33.5
Gender	Female	378	33.6
	Male	366	32.6
	Prefer not to say	380	33.8
Institution type	Private	568	50.5
	Public	556	49.5
Field of study	Agriculture and environmental studies	162	14.4
	Arts and design	153	13.6
	Business and management	154	13.7
	Computer science and IT	157	14
	Education	162	14.4
	Engineering and technology	180	16
	Health and medicine	156	13.9
Year of graduation	2025	269	23.9
	2026	295	26.2
	2027	279	24.8
	2028	281	25

5.2 Descriptive Statistics and Pearson Correlation Analysis

Table 3 presents the means, standard deviations, and Pearson correlation coefficients among the four dimensions of college–industry collaboration and graduate employability. The mean scores indicate moderate to high levels of engagement across all college–industry collaboration dimensions. Graduate employability also exhibited a moderately high mean value, suggesting generally positive perceptions of respondents' skills, job readiness, adaptability, and career confidence. The standard deviations indicate sufficient variability across all variables, supporting their suitability for correlational and regression analyses.

Pearson correlation analysis showed that curriculum development collaboration was positively and significantly correlated with graduate employability, $r(1122) = .451$, $p < .001$. This finding indicates that stronger alignment between curriculum design and industry needs is associated with improved employability outcomes among higher vocational graduates. Internship collaboration also demonstrated a positive and significant relationship with graduate employability, $r(1122) = .637$, $p < .001$, suggesting that structured workplace learning and hands-on industry exposure play a substantial role in

employability development. In addition, research project collaboration showed a strong and statistically significant association with graduate employability, r(1122) = .687, p < .001, indicating that participation in industry linked research and innovation activities is closely related to higher levels of job readiness, technical competence, and career confidence. Knowledge exchange collaboration was also significantly correlated with graduate employability, $r(1122) = .653$, $p < .001$, highlighting the importance of continuous interaction with industry professionals through workshops, mentoring, and professional engagement activities in supporting workforce readiness.

Significant positive intercorrelations were also observed among the four college–industry collaboration dimensions. Curriculum development collaboration was positively correlated with internship collaboration, $r(1122) = .506$, $p < .001$, and with knowledge exchange collaboration, $r(1122) = .426$, $p < .001$. Internship collaboration was significantly associated with research project collaboration, $r(1122) = .659$, $p < .001$, while research project collaboration was positively correlated with knowledge exchange collaboration, $r(1122) = .626$, $p < .001$. All correlation coefficients among the independent variables were below the recommended threshold of $r = .80$, indicating that multicollinearity was not a concern.

Table 3. Pearson Correlations Among Study Variables (N = 1,124)

Variable	1	2	3	4	5
1. Curriculum Development Collaboration	1				
2. Internship Collaboration	.506**	1			
3. Research Project Collaboration	.457**	.659**	1		
4. Knowledge Exchange Collaboration	.426**	.550**	.626**	1	
5. Graduate Employability	.451**	.637**	.687**	.653**	1

Note. Values are Pearson correlation coefficients. All correlations are significant at the .01 level (two-tailed).

p < .001 for all reported coefficients.

5.3 Multiple Regression Analysis and Hypothesis Testing

A multiple regression analysis was conducted to examine the extent to which curriculum development collaboration, internship collaboration, research project collaboration, and knowledge exchange collaboration predicted graduate employability (Table 4). The overall regression model was statistically significant, $F(4, 1119) = 401.56$, $p < .001$, indicating that the set of predictors reliably explained variance in graduate employability.

The model demonstrated strong explanatory power, with an R value of .768 and an R^2 of .589. This indicates that approximately 58.9% of the variance in graduate employability was explained by the four dimensions of college–industry collaboration. The adjusted R^2 of .588 further confirms the model's robustness after accounting for the number of predictors. The standard error of the estimate was .310, suggesting an acceptable level of prediction accuracy.

An examination of the regression coefficients revealed that all four dimensions of college–industry collaboration were significant predictors of graduate employability. Research project collaboration emerged as the strongest predictor ($\beta = .319$, $t = 11.29$, $p < .001$), indicating that students' involvement in industry-linked research and innovation activities had the greatest unique contribution to employability outcomes. Knowledge exchange collaboration was the second strongest predictor ($\beta = .300$, $t = 11.75$, $p < .001$), highlighting the importance of sustained interaction with industry professionals through mentoring, workshops, and professional

engagement.

Internship collaboration also demonstrated a significant and meaningful effect on graduate employability (β = .232, t = 8.51, p < .001), suggesting that structured work-based learning and hands-on industry exposure substantially enhance employment readiness. Curriculum development collaboration, while comparatively weaker, remained a statistically significant predictor (β = .060, t = 2.62, p = .009), indicating that industry-aligned curriculum design still plays an important supporting role in employability development.

Multicollinearity diagnostics indicated that collinearity was not a concern in the model. Tolerance values ranged from .459 to .703, and variance inflation factor (VIF) values ranged from 1.42 to 2.18, all well below the recommended threshold of 5. In addition, condition index values did not exceed critical levels, further confirming the absence of serious multicollinearity among the predictors.Overall, the regression results provide strong empirical support for all the hypotheses and confirm that different forms of college–industry collaboration contribute uniquely and significantly to graduate employability. The findings justify retaining all four collaboration dimensions in the final model and support their inclusion as key institutional mechanisms for enhancing workforce readiness among higher vocational graduates.

Table 4. Multiple Regression Analysis Predicting Graduate Employability (N = 1,124)

Predictor	B	SE B	β	t	p	Tolerance	VIF
Constant	0.399	0.08	—	4.964	< .001	—	—
Curriculum Development Collaboration	0.056	0.021	0.06	2.622	0.009	0.703	1.423
Internship Collaboration	0.221	0.026	0.232	8.508	< .001	0.495	2.019
Research Project Collaboration	0.322	0.029	0.319	11.286	< .001	0.459	2.177
Knowledge Exchange Collaboration	0.273	0.023	0.3	11.748	< .001	0.563	1.776

Model summary: $R = .768$, $R^2 = .589$, Adjusted $R^2 = .588$

ANOVA: $F(4, 1119) = 401.56$, $p < .001$

Dependent variable: Graduate Employability (GES)

Note. B = unstandardized coefficient; SE = standard error; β = standardized coefficient. All predictors were entered simultaneously.

6. Discussion

The findings of this study demonstrate that college–industry collaboration (CIC) exerts a substantial yet differentiated influence on graduate employability, reinforcing the argument that CIC should not be treated as a homogeneous construct. Both correlation and multiple regression analyses indicate that all four collaboration dimensions are positively and significantly associated with graduate employability; however, their relative explanatory power varies. The regression results show that research project collaboration emerged as the strongest predictor of graduate employability, followed by knowledge exchange collaboration, internship collaboration, and finally curriculum development collaboration. This pattern provides nuanced empirical support for employability theory, human capital theory, knowledge transfer theory, and collaborative learning theory, while clarifying how different forms of collaboration operate through distinct employability-enhancing mechanisms. Similar differentiated effects have been observed in recent studies showing that the depth and quality of industry-supported initiatives, including joint research, guest lectures, and skill-focused projects, produce stronger employability

outcomes than superficial partnership counts (Sadatcharapandian et al., 2022).

The dominant influence of research project collaboration highlights the critical role of industry-linked research and innovation activities in developing advanced employability attributes. From a human capital perspective, employability extends beyond basic skill acquisition to include higher-order competencies such as analytical reasoning, problem-solving, and innovation capacity (Becker, 1993; Yorke, 2006). Engagement in industry-sponsored research projects exposes students to complex, non-routine problems that resemble authentic workplace challenges, thereby strengthening their ability to integrate theoretical knowledge with practical application. This finding aligns with prior studies suggesting that applied research collaboration enhances graduates' capacity for

critical thinking and adaptive expertise, particularly in innovation-driven economic contexts (Toner, 2011; Gube & Lajoie, 2020). Similar evidence from precision and applied engineering programmes further supports the argument that research-based and project-driven learning environments foster higher employability by improving problem-solving and innovation skills (Adeleke et al., 2024). In the context of Jinan, where industrial upgrading and technological transformation are ongoing, research collaboration appears to serve as a high-impact mechanism for enhancing employability, equipping graduates with competencies valued in knowledge-intensive sectors.

Knowledge exchange collaboration emerged as the second strongest predictor of graduate employability, underscoring the importance of sustained interaction between vocational institutions and industry partners. Knowledge transfer theory posits that employability development is facilitated not only through formal learning but also through the circulation of tacit knowledge, professional norms, and industry expectations (Nonaka & Takeuchi, 1995; O'Connor, 2022). Employer-led seminars, guest lectures, mentoring, and structured career guidance enable students to internalise current labour market requirements and professional cultures. The strong relationship between knowledge exchange and employability observed in this study is consistent with recent research showing that ongoing university–business cooperation enhances innovation capacity, skill alignment, and career readiness, particularly when institutional networks support sustained collaboration (Yessimova et al., 2023). Likewise, Outcome-Based Education frameworks that integrate guest lectures and mentorship have been found to enhance graduates' communication and leadership skills (Sobri et al., 2025). Although knowledge exchange activities may not always involve direct skill practice, their influence appears substantial because they shape students' understanding of workplace realities and support informed career planning.

Internship collaboration also demonstrated a significant and meaningful contribution to graduate employability, consistent with collaborative learning theory. From a Vygotskian perspective, learning is enhanced through social interaction, guided participation, and engagement with more experienced practitioners (Vygotsky, 1978). Structured internships allow students to acquire transferable skills, internalise workplace norms, and construct professional identities through authentic participation. The results align with prior evidence indicating that internships positively influence employability when they are well structured and embedded within institutional support systems (Bridgstock, 2009; Chen & Wu, 2023). Empirical studies have also shown that internships and quasi-virtual work experiences enhance critical thinking, teamwork, and professional confidence, thereby helping to bridge the academic–industry divide (Howell et al., 2024). However, the comparatively weaker effect of internship collaboration relative to research and knowledge exchange suggests that experiential learning alone may be insufficient when it is not systematically integrated with innovation-oriented tasks or reflective learning processes. By contrast, curriculum development collaboration, although statistically significant, exhibited the weakest unique effect on graduate employability in the regression model. This finding does not diminish the importance of curriculum alignment but rather suggests that curriculum collaboration may operate as a foundational

mechanism whose effects are partly mediated through other forms of collaboration. Employability theory emphasises that curriculum relevance is necessary but not sufficient for employability development (Yorke, 2006; Atkins et al., 2011). While industry participation in curriculum design helps reduce skills mismatches and enhance labour-market relevance (Li et al., 2024), its direct impact on employability outcomes may be less pronounced than that of collaboration forms that involve deeper engagement, such as applied research and sustained knowledge exchange. This interpretation is consistent with post-COVID higher education strategy research, which argues that curriculum reform must be complemented by experiential, innovative, and relational learning opportunities to achieve meaningful employability gains (Rasli et al., 2022). Moreover, studies evaluating the Merdeka Belajar–Kampus Merdeka policy in Indonesia confirm that curriculum reform leads to significant improvements in employability only when paired with industry-linked projects and the integration of digital skills (Saa, 2025). Collectively, these findings challenge policy approaches that prioritise the quantitative expansion of college–industry collaboration, such as increasing the number of partnerships or memoranda of understanding. Instead, the results suggest that employability gains depend on the depth, quality, and institutional embedding of collaboration. Research project collaboration and knowledge exchange generate stronger employability returns because they actively engage students in knowledge creation, professional interaction, and adaptive learning. Internship collaboration remains important but is most effective when integrated with reflective and innovation-oriented activities. Curriculum development collaboration provides a necessary structural foundation but requires reinforcement through more immersive forms of collaboration to maximise its impact. These insights are particularly relevant for vocational systems in emerging economies, where superficial or symbolic collaboration risks diluting rather than strengthening vocational identity and graduate employability (Zhao & Xie, 2021; Zhang & Yang, 2021; Zhou & Wu, 2024).

7. Conclusion

This study provides robust empirical evidence that college–industry collaboration (CIC) plays a significant role in enhancing graduate employability in higher vocational education, while also demonstrating that different forms of collaboration contribute unequally. By disaggregating CIC into curriculum development collaboration, internship collaboration, research project collaboration, and knowledge exchange collaboration, the study shows that research-oriented and relational forms of collaboration most strongly influence employability outcomes. In particular, research project collaboration emerged as the strongest predictor of graduate employability, followed by knowledge exchange collaboration and internship collaboration, while curriculum development collaboration, although significant, exerted the weakest unique effect.These findings advance theoretical understanding by reinforcing a differentiated conceptualization of CIC that aligns with employability theory, human capital theory, collaborative learning theory, and knowledge transfer theory. The results suggest that employability development extends beyond curriculum relevance and workplace exposure to include higher-order capabilities such as problem-solving, innovation, adaptability, and professional identity formation. Research project collaboration and knowledge exchange are especially effective because they engage students in complex problem-solving, tacit knowledge acquisition, and sustained interaction with industry professionals, thereby strengthening advanced employability attributes.

Empirically, the study provides context-specific evidence from Jinan, illustrating how vocational institutions operating in an industrial-upgrading environment translate collaboration into employability outcomes. The findings indicate that while curriculum alignment and internships provide an important structural foundation, deeper forms of engagement, particularly industry-linked research and continuous knowledge exchange, generate stronger employability returns. At the same time, the comparatively weaker effect of curriculum development collaboration suggests that curriculum reform alone is insufficient unless

reinforced by immersive, applied, and relational learning opportunities. From a practical and policy perspective, the results caution against approaches that prioritise the quantitative expansion of collaboration networks, such as increasing the number of partnerships or formal agreements, without attention to their functional quality. Instead, policymakers and institutional leaders should prioritise the qualitative deepening of collaboration by embedding industry-linked research projects, strengthening mechanisms for sustained knowledge exchange, and ensuring that internships are structured, supervised, and integrated with reflective and innovation-oriented learning processes. Curriculum co-design remains necessary but should be positioned as a foundational mechanism that supports rather than substitutes for more immersive collaboration.

Overall, this study underscores that effective college–industry collaboration depends not on symbolic compliance or partnership counts, but on how collaboration is designed, governed, and embedded within vocational education systems. For vocational institutions seeking to enhance graduate employability, strategic emphasis should be placed on applied relevance, depth of engagement, and institutional accountability to ensure that collaboration translates into meaningful and sustainable employment outcomes.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interest

The authors declare that they have no conflict of interest.

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