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Enhancing Talent Development through Strategic Industry Partnerships: A Moderated Mediation Model of Enterprise Support and Teacher Competence in Resource-Intensive Vocational Colleges in Shanxi, Inner Mongolia, and Shaanxi, China

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Abstract

Background and Aim: China's coal-oriented vocational institutions are facing mounting pressure to raise the standard of talent development in the face of rapid industrial transformation and growing demands for safety, digitization, and sustainable practices. Industry-education integration, or IEI, is a key strategy to bridge the gap between vocational training and labor market demands. However, little is known about how IEI improves educational outcomes, particularly in resource-intensive disciplines. This study aims to comprehend the internal dynamics of IEI by examining the moderating impact of instructors' professional competency and the mediating role of industry assistance on the caliber of talent development in coal-focused vocational schools.

Materials and Methods: A quantitative, cross-sectional design was employed. The poll included 512 respondents from 15 coal-focused vocational colleges in China's three primary coal-producing regions: Shaanxi, Inner Mongolia, and Shanxi. Respondents included faculty, department heads, and academic administrators. The following important constructs were measured using validated multi-item measures with a 5-point Likert scale: industry-education integration, instructors' professional competence, corporate assistance, and the caliber of talent development. Structural equation modeling (SEM) was utilized to assess direct and mediated effects, and PROCESS Macro (Model 14) was employed to analyze moderated mediation. By using statistical controls and procedural separation, common method bias was mitigated.

Results: The results showed that the association between IEI and talent development quality is significantly mediated by enterprise support ($\beta = 0.396$, $p < 0.001$), suggesting that enterprise engagement is the main way that IEI improves outcomes. Additionally, the influence of enterprise support on talent outcomes is moderated by teachers' professional competence (interaction $\beta = 0.211$, $p < 0.01$), meaning that highly qualified and industry-adaptable instructional staff have a greater impact on enterprise contributions. The moderated mediation was statistically significant, supporting the idea that internal capacity determines how effective external help is.

Conclusion: This study highlights a dual-pathway model for vocational education reform in resource-dependent settings, which requires external enterprise involvement to complement internal instructional preparation in order to achieve observable educational advances. Policies that support IEI should prioritize the creation of dual-qualified teaching staff and institutionalize enterprise support systems. These findings contribute to theoretical knowledge of IEI implementation and practical strategies for improving the quality of vocational training in the coal sector and elsewhere.

Keywords: Industry-education Integration; Enterprise Support; Teacher Professional Competence; Talent Development Quality; Coal Vocational Education

Introduction

Driven by the energy revolution and high-quality development, vocational education is facing growing pressure to meet the needs of high-quality development and industrial upgrading in resource-based industries, such as coal, petroleum, and electric power. Coal-oriented vocational colleges have become the major source of human resources for the coal industry. In addition to the traditional role of coal-oriented vocational colleges in providing labor supply for the coal industry, the new requirement is to cultivate technical talents who can master new technologies, green production, and smart mines. At present, there are many problems with coal-oriented vocational colleges, such as the lack of curriculum modernization, weak enterprise involvement, and imperfect coordination between theory and practice.

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One of the hot solutions put forward in recent years is to integrate industry and education (IEI). The IEI framework is mainly based on systems theory and human capital theory, which requires enterprise participation in the whole talent training value chain, including curriculum co-design, the construction of joint training platforms, and joint certification. The research on IEI is currently in a theoretical exploration stage, and most of the existing research is at the macro level, such as institutional design and policy implementation, including government funding, incentive policies, system reforms, regional collaboration platforms, and so on. However, there is still a lack of in-depth research on the specific mechanism of IEI in improving talent development.

One of the key but underexplored variables in IEI is enterprise support, including both "hardware" support (financial support, equipment, instructors) and "software" support (knowledge sharing, experience, and guidance). According to resource dependence theory and knowledge transfer theory, enterprise support is an important intermediary mechanism through which IEI can promote improvement in talent development quality. However, there is no guarantee that enterprise support will be effective. The strength of IEI implementation depends on the institutional environment. In this process, the internal institutions also play an indispensable role in the actual effect of IEI.

The most important element is the professional competence of teachers. The core involves professional knowledge, teaching skills, and the ability to convert practical experience into teaching. The logic of bringing teacher competence into the model as a moderating variable is theoretically explained by two schools of thought. First, educational psychology argues that all learning and development are functions of the interaction between the learner and the environment. Second, absorptive capacity theory points out that there is a positive correlation between the individual and the internal capabilities of the organization, and the better the individual and organizational compatibility, the higher the organizational performance. In this process, teacher competence can play a moderating role in improving talent development quality through enterprise support. If teachers have high levels of professional competence, they are more capable of absorbing enterprise resources and finally completing resource conversion into quality teaching for students.

Accordingly, this study has the following two research questions: What is the mediating role of enterprise support in the relationship between IEI and talent development quality in coal-oriented vocational colleges? Does teacher competence as a moderator play a role in the relationship between enterprise support and talent development quality? This study, by building a moderated mediation model, examined both mediating and moderating mechanisms and empirically analyzed how internal and external factors affected talent development quality. This research could help deepen the theoretical explanation of IEI implementation and promote IEI governance and policy refinement. The contributions of this study can be summarized as threefold. First, it empirically verified the mediating role of enterprise support. Second, it selected teacher competence as a moderating variable and verified its boundary effect on enterprise support. Third, it provided IEI implementation policy implications for achieving resource industry governance and promoting high-quality vocational education by coordinated enterprise participation and teacher competence improvement.

Objectives

This study aims to investigate how industry-education integration (IEI) enhances talent development quality in coal-oriented vocational colleges by examining the mediating role of enterprise support and the moderating role of teachers' professional competence. It seeks to validate a moderated mediation model that captures the interaction between external industry engagement and internal instructional capacity in shaping educational outcomes.

Literature review

The concept of industry-education integration (IEI) has shifted from a policy slogan to a strategic mechanism aimed at reconciling the long-standing disconnect between vocational education and labor

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market demands. Existing literature broadly affirms IEI's potential to enhance the practical relevance and adaptability of vocational training, particularly by embedding real-world industrial elements into educational systems. However, while this consensus is well established, a closer synthesis of the literature reveals significant conceptual and empirical gaps, especially about the mechanisms through which IEI influences educational outcomes and the contextual variability of its effectiveness.

1. From Structural Intent to Operational Mechanism: Ei's Unfinished Agenda

Multiple studies have demonstrated that IEI improves talent cultivation by aligning curricula with industrial needs and fostering collaboration between colleges and enterprises. For example, Ouyang (2025) and Tian (2025) underscore how co-designed programs and enterprise-led internships improve students' applied skills in fields like industrial internet and computer science. These findings are echoed in regionally focused studies, such as Wen et al. (2025) in Guangdong, which point to persistent systemic challenges—namely inconsistent investment, talent mismatches, and fragmented policy enforcement—that hinder IEI's full implementation.

Despite this growing body of evidence, these studies predominantly adopt macro-level perspectives, focusing on institutional design or policy frameworks. What remains underexplored are the micro-level dynamics that determine whether and how IEI materializes into improved educational outcomes within specific sectors. Notably, most empirical research fails to address how IEI interventions are internalized at the institutional and instructional levels, especially in specialized contexts like coal-related vocational education. This study seeks to fill this void by operationalizing and empirically testing IEI's internal mechanisms.

2. Enterprise Support: Beyond Participation to Mediation

A critical, though often underexamined, component of effective IEI is enterprise support—defined as the provision of tangible (e.g., Equipment, funding) and intangible (e.g., technical expertise, mentorship) resources by enterprises. While earlier research affirms its value, the function of enterprise support is typically treated as an implicit assumption rather than a formally theorized mechanism.

Liu (2021) attempts to quantify enterprise involvement through patent data, revealing a positive correlation between institutional collaboration and innovation output. Similarly, Chen (2018) focuses on the coal sector, advocating for deeper school-enterprise collaboration to meet sector-specific skill needs. Cheng (2024) further critiques the weak alignment between professional education and industrial structures, attributing it to an inadequate systemic integration of enterprise input.

These studies, while insightful, fall short of conceptualizing enterprise support as a mediating construct—that is, a functional channel through which IEI translates into educational effectiveness. This study addresses that gap by empirically testing enterprise support as a mediator in the IEI–talent development relationship, thereby advancing both theoretical and practical understanding of its causal role.

3. Teacher Competence: The Overlooked Moderator

An equally important yet seldom theorized factor in IEI success is the professional competence of teachers. Though often discussed in passing, few studies systematically examine how teacher quality conditions the impact of external enterprise inputs. Liu Na (2022) identifies underinvestment in faculty development as a major barrier to IEI implementation in Ordos, while Chen (2019) and Liu Ling (2018) critique the lack of dual-qualified teachers capable of integrating industry practices into pedagogy.

These findings imply that teacher competence may moderate the effectiveness of enterprise support, serving as a critical boundary condition. However, the literature has yet to conceptualize or empirically validate this interaction. Drawing on absorptive capacity theory and educational psychology, this study theorizes that highly competent teachers are better positioned to internalize and apply enterprise-provided resources, thereby enhancing talent development outcomes.

4. Gaps and Novel Contributions

The review above highlights several key gaps in the existing literature:

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Lack of Mechanistic Clarity: The causal pathway from IEI to educational outcomes remains insufficiently theorized, particularly the role of enterprise support as an intermediary mechanism.
Neglect of Interaction Effects: The moderating role of internal institutional capacity—especially teacher competence—has not been formally tested.

Contextual Blind Spots: Möst research treats IEI as a generalizable model, with limited attention to its operation in resource-intensive, safety-critical sectors like coal, where the demands for technical precision and industrial compliance are uniquely stringent.

This study responds to these gaps by constructing a moderated mediation model that captures both the conditional(moderation)and processual(mediation)elements of IEI effectiveness. By applying this model to coal-oriented vocational education—a domain often marginalized in mainstream IEI research—it makes a novel theoretical and empirical contribution to both sector-specific educational policy and the broader discourse on collaborative education governance.

As China's vocational education system transforms—particularly in coal-dependent regions where industrial safety, technological modernization, and sustainable development are paramount—it becomes essential to understand not just whether industry-education integration (IEI)works, but how and under what conditions it leads to improved talent development outcomes. Rather than assuming a linear relationship, this study adopts a moderated mediation framework that theorizes enterprise support as a mediating mechanism and teachers 'professional competence as a moderating factor. This integrated approach draws upon systems theory, resource dependency theory, knowledge transfer theory, and absorptive capacity theory, weaving them into a cohesive explanatory model tailored to the realities of coal-oriented vocational education.

1. Industry-Education Integration as a Strategic Input (Systems Resource Dependency Theory)

Rooted in systems theory, IEI is conceptualized as a structural reform strategy that embeds enterprise engagement across the vocational education system, including curriculum co-design, shared instructional resources, internships, and assessment. In this context, the education system is not an isolated entity but part of a broader socio-economic network in which external industrial actors become integral components of the training pipeline.

Further, resource dependency theory underlines that vocational colleges—especially those in coal-dependent areas—rely heavily on external resources (e.g., funding, facilities, expertise) provided by enterprises to survive, adapt, and evolve. As such, IEI is not merely about coordination; it is a strategic necessity driven by asymmetrical resource relationships between schools and industry.

2. Enterprise Support as a Mediating Mechanism (Knowledge Transfer Theory)

Although IEI sets the structural stage for collaboration, its efficacy depends on the extent and quality of enterprise support, which operationalizes integration through tangible contributions such as technical equipment, funding, personnel, and access to real-world training environments. Drawing on knowledge transfer theory, enterprise support represents the vehicle through which industrial knowledge and practices flow into educational settings.

In this framework, enterprise support is not a passive outcome of policy but an active mediating channel. Without sufficient and sustained enterprise engagement, IEI risks becoming symbolic rather than substantive. Therefore, enterprise support is posited to mediate the relationship between IEI and educational quality, transforming institutional arrangements into functional pedagogical outputs.

3. Teacher Competence as a Moderating Factor (Absorptive Capacity Human Capital Theory)

Even when enterprise support is present, its impact on talent development is not uniform. Here, teachers' professional competence—comprising subject knowledge, pedagogical innovation, and industry adaptability—becomes the key internal factor determining whether enterprise-provided resources are effectively utilized.

From the lens of absorptive capacity theory, educational institutions must possess the internal capability to recognize, assimilate, and apply external knowledge. Teachers serve as the conduit for this

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process. A competent faculty enhances the institution's ability to internalize enterprise inputs and translate them into meaningful learning outcomes.

This logic is reinforced by human capital theory, which asserts that the effectiveness of education depends on the quality of those delivering it. Thus, teacher competence is hypothesized to moderate the relationship between enterprise support and talent development quality, amplifying or attenuating the effectiveness of external engagement based on internal instructional capacity.

4. Talent Development Quality as the Dependent Outcome

In this study, talent development quality is defined as the extent to which vocational graduates meet the evolving skill demands of the coal industry, including safety compliance, digital literacy, and environmental awareness. AS the ultimate output of the education system, it reflects both the alignment with industrial needs and the internal pedagogical effectiveness of vocational colleges.

5. Model Structure and Hypotheses

Based on the integrated theoretical logic, this study proposes a moderated mediation model comprising the following hypotheses:

H1: Industry-education integration has a positive effect on enterprise support.

H2: Enterprise support positively influences the quality of talent development.

H3: Enterprise support mediates the relationship between IEI and talent development quality.

H4: Professional competence moderates the relationship between enterprise support and talent development quality, such that this relationship is stronger when teacher competence is high.

This framework captures both the systemic interdependence between education and industry and the institutional contingency inherent in policy implementation. It provides a theoretically rigorous and context-sensitive model for analyzing how IEI can deliver meaningful educational outcomes in coal-oriented vocational colleges, where training effectiveness is critical not only for employment but also for industrial safety, energy efficiency, and regional sustainability.

Methodology

This study adopts a quantitative research design grounded in positivist epistemology to empirically test the hypothesized moderated mediation model. The methodological framework is structured to examine not only the direct and indirect effects of industry-education integration (IEI)on talent development quality but also the conditional moderating role of teachers' professional competence. To ensure analytical rigor, the study integrates structured survey methods with structural equation modeling (SEM)to analyze complex, multivariate relationships among latent constructs.

1. Research Design and Sampling Justification

A cross-sectional survey was administered across 15 coal-oriented higher vocational colleges located in Shanxi, Inner Mongolia, and Shaanxi—three provinces that collectively account for a substantial proportion of China's coal output and host a dense cluster of vocational institutions with sector-specific mandates. The rationale for selecting these regions lies in their strategic relevance: they are not only key pillars of the national coal industry but also policy focal points for vocational education reform, particularly in the context of industrial upgrading, digitalization, and green transition.

The sampled colleges were selected using a stratified random sampling strategy, stratified by geographic region, institutional type (public vs. Private), and level of enterprise engagement. This design enhances representativeness while allowing for controlled variation in key institutional characteristics. Target respondents included teaching staff, department heads, and academic administrators involved in curriculum development and enterprise collaboration.

This hypothesis-driven design supports the empirical validation of a theoretically grounded model and is appropriate for modeling latent constructs and testing conditional process pathways.

2. Variable Operationalization and Measurement

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All core constructs—eEnterprise support, teachers 'professional competence, and talent development quality—were operationalized as second-order latent variables, each measured through multiple validated indicators adapted to the coal vocational context.

Industry-Education Integration (IEI): Measured using items related to joint curriculum development, shared instructional resources, co-supervised internships, and formalized enterprise collaboration (Wen et al., 2025; Ouyang, 2025).

Enterprise Support (ES): Captured through financial support, provision of technical equipment, participation of enterprise personnel in teaching, and on-site training platforms (Liu, 2021; Chen, 2018).

Professional Competence (TPC): Assessed via dimensions such as dual-qualification status, pedagogical innovation, industry experience, and responsiveness to industrial trends (Liu Na, 2022; Chen, 2019).

Talent Development Quality (TDQ): Evaluated using employer satisfaction, graduate employability, skill alignment with industry needs, and adaptability in intelligent mining environments (Cheng, 2024; Wan et al., 2025).

All items were rated on a 5-point Likert scale (1=strongly disagree to 5=strongly agree). A pilot test with 60 participants was conducted to assess content validity, item clarity, and scale reliability, leading to minor wording adjustments for contextual precision.

3. Common Method Bias Control

Given the use of self-report questionnaires, the potential for common method bias (CMB)was acknowledged and addressed through both procedural and statistical remedies:

Procedural strategies included clear item wording, psychological separation of constructs (i.e., mixing item blocks), and assurances of anonymity to reduce social desirability bias.

Statistical controls included Harman's single-factor test, which showed that no single factor accounted for the majority of variance, and the use of confirmatory factor analysis (CFA)to ensure construct discriminant validity. Additionally, variance inflation factors (VIFs)were examined and found to be below critical thresholds, indicating low multicollinearity.

These steps collectively mitigate CMB risk and support the robustness of the findings.

4. Data Collection and Response Rate

A total of 620 questionnaires were distributed both online and in paper form, yielding 512 valid responses (response rate=82.6%). Respondents were briefed on the purpose of the research, and informed consent was obtained in compliance with institutional ethical guidelines. Participation was voluntary, and all data were anonymized to protect respondent confidentiality.

5. Data Analysis Procedures

The data analysis followed a two-stage approach:

Measurement Model Evaluations were conducted to assess internal consistency (via Cronbach'sα), convergent validity (via average variance extracted, AVE, and composite reliability, CR), and discriminant validity (using the Fornell–Larcker criterion).

Structural Model Testing: SEM was conducted using AMOS 26.0 to evaluate the hypothesized relationships. The mediating effect of enterprise support was tested using bootstrapping with 5,000 resamples, while the moderating and moderated mediation effects of teacher competence were tested using PROCESS Macro (Model 14), in line with Hayes (2013).

Model fit was assessed using multiple indices: $\chi^2/df=2.371$; RMSEA=0.056; CFI=0.943; TLI=0.928; SRMR=0.043—indicating acceptable model fit.

Ethical Considerations

This study was conducted in accordance with academic research ethics. Participants were informed of the study's purpose and assured that their responses would remain confidential. No personally identifiable information was collected, and all procedures received institutional ethical clearance.

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Results

This section presents the empirical results of the study in three stages:(1) validation of the measurement model, (2) testing of the structural model including the mediation mechanism, and (3) examination of the moderation and moderated mediation effects. Beyond statistical significance, the findings are interpreted in terms of their practical implications for enhancing talent development in coal-oriented vocational colleges.

1. Measurement Model Evaluation

To evaluate the validity and reliability of the constructs, a confirmatory factor analysis (CFA) was conducted. The results indicated strong internal consistency across all latent variables, with Cronbach's alpha values ranging from 0.871 to 0.926, well above the recommended threshold of 0.70. In terms of convergent validity, the composite reliability (CR) scores were all above 0.85, and average variance extracted (AVE) values ranged from 0.61 to 0.73, indicating that the constructs adequately captured the variance in their respective indicators. Discriminant validity was confirmed using the Fornell–Larcker criterion, as the square root of each construct's AVE exceeded its inter-construct correlations. The overall model fit indices further supported the robustness of the measurement model, as shown in Table 1. These results collectively demonstrate that the constructs are statistically sound and appropriate for subsequent structural equation modeling.

Table 1 Measurement Model Fit Indices

Fit Index	Value	Threshold
χ^2/df	2.371	< 3.00 (acceptable)
RMSEA	0.056	< 0.08 (good)
CFI	0.943	≥ 0.90 (acceptable)
TLI	0.928	≥ 0.90 (acceptable)
SRMR	0.043	< 0.08 (good)

2. Structural Model and Mediation Analysis

Structural equation modeling (SEM) was employed using AMOS 26.0 to assess the hypothesized relationships among the core variables. The results strongly supported all three hypotheses. First, Industry-Education Integration (IEI) was found to significantly predict Enterprise Support ($\beta = 0.684$, $p < .001$), confirming Hypothesis 1 (H1). Second, Enterprise Support significantly influenced Talent Development Quality ($\beta = 0.579$, $p < .001$), affirming Hypothesis 2 (H2). Third, Hypothesis 3 (H3) was supported, as the indirect effect of IEI on Talent Development Quality through Enterprise Support was statistically significant (standardized indirect effect = 0.396, $p < .001$). Notably, the direct path from IEI to Talent Development Quality remained significant ($\beta = 0.278$, $p < .01$), indicating a partial mediation model.

To validate the mediation effect, a bootstrapping method with 5,000 resamples was applied. The 95% bias-corrected confidence interval for the indirect effect ranged from 0.317 to 0.486 and did not include zero, thus confirming the robustness of the mediating role played by enterprise support.

Practically, these findings emphasize that enterprise support is not a peripheral activity but a core mechanism for translating high-level IEI policies into concrete educational outcomes. High-quality enterprise involvement—through mechanisms such as joint curriculum development, internships, and shared resources—enhances the alignment between vocational education and the needs of the labor market, particularly in coal-sector vocational training, where technical expertise and safety practices are paramount.

Table 2 Structural Model Path Coefficients

Path	Standardized Coefficient (β)	*p*-value
IEI → Enterprise Support	0.684	< .001
Enterprise Support → Talent Development Quality	0.579	< .001
IEI → Talent Development Quality (Direct)	0.278	< .01

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Path	Standardized Coefficient (β)	*p*-value
IEI → Talent Development Quality (Indirect)	0.396	< .001

3. Moderation and Moderated Mediation Analysis

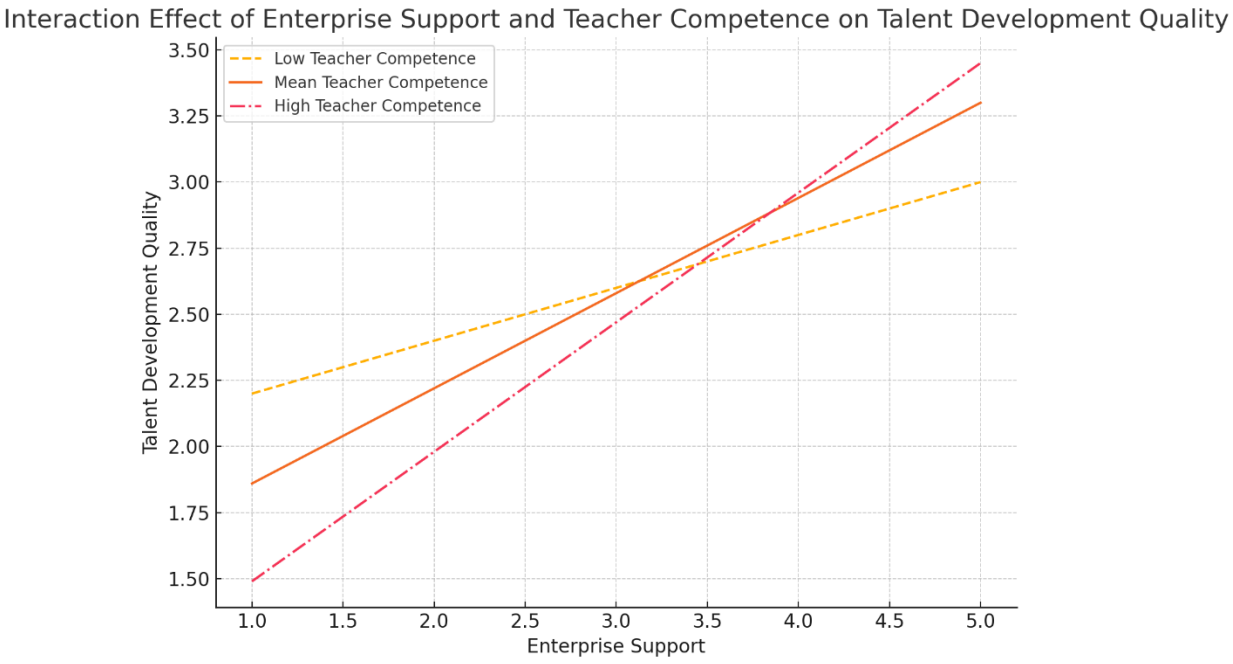
To evaluate Hypothesis 4 (H4), hierarchical regression and interaction effect analyses were conducted. The interaction term between Enterprise Support (ES) and Teachers' Professional Competence (TPC) was statistically significant (β = 0.211, p < .01), indicating that teacher competence moderates the relationship between enterprise support and talent development. Specifically, the positive influence of enterprise support on talent development quality is amplified when teacher competence is high.

To further examine this dynamic, a moderated mediation analysis was conducted using PROCESS Macro (Model 14). The results revealed a conditional indirect effect:

- When teacher competence was high, the indirect effect of Enterprise Support on Talent Development Quality was 0.487 (95% CI [0.399, 0.581]).
- When teacher competence was low, the indirect effect decreased to 0.321 (95% CI [0.233, 0.405]).
- The index of moderated mediation was 0.128 (95% CI [0.072, 0.193]), confirming that teacher competence strengthens the mediating role of enterprise support.

Table 3 Moderated Mediation Analysis

Teacher Competence Level	Indirect Effect	95% Confidence Interval
High	0.487	[0.399, 0.581]
Low	0.321	[0.233, 0.405]
Moderated Mediation Index	0.128	[0.072, 0.193]



Conclusion

This study confirms a nuanced and interdependent mechanism by which industry-education integration (IEI) enhances talent development quality in coal-oriented vocational colleges. The findings

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demonstrate that enterprise support acts as a significant partial mediator, linking IEI to educational outcomes both directly and indirectly. Moreover, teachers' professional competence significantly moderates this relationship, intensifying the positive effects of enterprise engagement when instructional quality is high. Collectively, these results underscore the importance of aligning external industry collaboration with strong internal faculty capabilities to effectively elevate vocational education standards and better meet labor market demands.

Discussion

This study provides empirical evidence for the internal mechanisms through which industry-education integration (IEI)enhances talent development quality in coal-oriented vocational colleges. Validating a moderated mediation model sheds light on how enterprise support and teacher competence interact to shape educational outcomes. The findings offer both theoretical advancement and practical insights, while also prompting further inquiry into contextual and methodological complexities.

1. Theoretical Contributions

This study makes several important contributions to the existing literature on vocational education and collaborative governance between educational institutions and industrial sectors. First, the empirical findings support the argument that IEI by itself does not automatically lead to better educational outcomes and that its impact is, in fact, partially mediated by enterprise support. This finding resonates with the concerns raised in previous literature (Wen et al., 2025; Cheng, 2024) about the potential pitfalls of overemphasizing top-down structural approaches to integration. By empirically validating the mediating role of enterprise support, this study not only enriches resource dependency theory and collaborative governance theory but also offers practical guidance for schools to be more proactive in utilizing the resources provided by industry partners instead of simply depending on formal cooperation arrangements. Second, the introduction of teacher professional competence as a moderating variable extends the theoretical scope of absorptive capacity in the specific context of vocational education. The finding that external resources (enterprise support) are not sufficient to bring about positive educational outcomes without the presence of certain internal capabilities (teacher competence) complements the insights offered by human capital theory and further highlights the importance of qualified instructors in the transfer of external resources to students. Third, this study addresses a significant gap in the literature by developing an industry-specific empirical model that focuses on the coal sector, a field that has received relatively limited attention compared to other strategically important industries in China. The finding that the IEI of this industry is, in certain aspects, more complex and, thus, needs to be further tailored to account for its unique characteristics (safety rules, digitalized underground mining equipment, etc.) broadens the research in vocational education and makes it more nuanced and transferable in the context of resource-dependent economies.

2. Practical Implications

In addition to providing theoretical implications, this paper also puts forward practical suggestions for relevant decision-makers, college leaders, and cooperative enterprises:

2.1 Standardize and motivate the cooperation of enterprises

Although many vocational colleges have cooperation agreements with local enterprises, few standard operating procedures are directly transformed into resource support after the signing of the agreement. Decision-makers can standardize and motivate enterprises to actively contribute, for example, through tax rebates, co-branding, or government-matched investments, so that enterprises are willing to directly and actively participate in the development of professional syllabi, the sharing of equipment, the exchange of teachers, and investment in the training base. At the same time, the Ministry of Education and local governments can also include the evaluation of enterprise cooperation quality and results in the accreditation of vocational colleges.

2.2 Formulate a system of Dual-Qualified Teachers

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Teacher quality is also an important endogenous factor affecting the impact of IEI. Vocational colleges should design a Dual-qualified Teacher system at different time scales. (1) Set up short-term training tasks for teachers to immerse themselves in the industry to update skills; (2) In the medium term, colleges and enterprises can implement co-teaching mechanisms; and (3) In the long run, vocational colleges can design a sabbatical mechanism to drive teachers to enter enterprises and participate in R&D or production and operation in depth. These training systems can be connected with financial funding and included in the annual assessment index of teachers to promote motivation.

2.3 Participate in the industrial planning of the local area

Professional layout, courses, and applied research of vocational colleges in coal areas must be based on the adjustment of local coal industry technology and the regulation system to make corresponding adjustments. Colleges can carry out joint prediction and needs forecasting of new skills and talents in the local area, and actively participate in the regional innovation ecology to create synergy.
d. Build an IEI assessment system and an information system

A timely and accurate IEI assessment system can effectively drive the optimization and upgrading of IEI cooperation. Vocational colleges should establish a student employment situation, employer satisfaction, and resource input-output dynamic data system to provide an objective basis for IEI policy research.

3. Limitations and Alternative Explanations

Several limitations of the current study should be noted:

Cross-sectional design and causality limitations: Although the current study found that enterprise support and teacher competence were statistically significant predictors of talent development quality, the cross-sectional data cannot determine the direction of causality with complete certainty. For example, it is plausible that better-resourced or more esteemed institutions may have a higher capacity to attract enterprise support rather than vice versa. A longitudinal or quasi-experimental design is advised for future research to rule out such alternate interpretations.

Risk of omitted variable bias: In the current study, enterprise support and teacher competence were included as key independent variables, while other possible institutional factors that could impact talent development were not controlled for in the model. For instance, factors at the student level (e.g., motivation, prior knowledge/skill levels), school leadership (e.g., the principal's vision for IEI and departmental autonomy), culture and readiness for change at the organizational level, or contextual policy environment (e.g., local government encouragement or pressure) might also be potential explanatory variables. Future studies could incorporate such variables to further disentangle the relative contributions of endogenous (i.e., "internal") and exogenous (i.e., "external") drivers.

Common method bias and construct measurement: The use of a single-source, self-reported data collection instrument may have introduced common method bias. Although the current study took precautions to reduce potential CMBs (e.g., procedural remedies, CFA), they remain a consideration. Future research would benefit from data triangulation, e.g., by supplementing the survey responses with student learning outcomes data, enterprise feedback forms, or independent classroom observations.

The present research has shed light on the phenomenon of "policy to practice": how the policy goal of talent development is enacted on the ground. As a social phenomenon that is emergent at both micro- and macro-levels, the model does not claim to be a comprehensive representation of talent development processes in the vocational sector. However, by linking specific elements of policy (external) to a key educational outcome (talent development), the model advances the current research on IEI in coal-oriented vocational colleges in several respects. First, the study moves beyond identifying general trends by pointing to both external and internal factors that are likely to influence the final outcome of talent development quality. This finding is meaningful given the study's geographical and institutional context. For coal-oriented vocational colleges, the quality of talent development is an especially critical concern due to the safety, efficiency, and sustainability implications for the energy sector. In this regard, the

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current study points to a new focus in the educational reform: the IEI and talent development problem in coal-oriented vocational colleges needs to be understood and addressed in an integrated manner.

The results imply that while IEI appears to work best when external support is institutionalized, internal instructional capacity should not be neglected. Therefore, the co-evolutionary approach that takes into account enterprise engagement, faculty development, and education reform is a desirable solution for both policymakers and schools. In other words, enhancing talent development quality in resource-based vocational education is not only about designing effective policies – it is also about strategic planning, collaboration, smart investment, and continuous capacity building.

Conclusion

Using the mediating effect model and the moderating effect model, this paper conducts an empirical analysis on how IEI improves the quality of talent cultivation in coal-oriented higher vocational colleges. Based on the collaborative governance theory, this paper verified that the participation of industry subjects, as an institutional arrangement form of IEI, affects the quality of talent cultivation through enterprise support, and the process is moderated by the dual-qualified teachers' professional competence. This paper's research conclusion not only expands the academic theory but also enriches the pragmatic perspective on IEI reform and development. The practical enlightenment is that we can further IEI reform by institutionalizing the participation of enterprises and cultivating a batch of dual-qualified talents. After all, the coal industry in China is in a critical period of digital and sustainable development. To improve the quality of talent cultivation, it is not only necessary to increase the support of industry subjects but also to improve the vocational college's ability to accept and absorb.

Recommendation

Based on the research conclusions, this article puts forward the following policy suggestions based on empirical research, theoretical analysis, and a certain degree of subjective practices and implementations, to contribute to the IEI and sustainable development of a high-quality coal-related vocational talent cultivation mode in higher vocational colleges. The suggestions are as follows.

Firstly, it is necessary to standardize the enterprise participation mechanism. The phenomenon of sporadic participation of enterprises in IEI should be avoided. On the one hand, the government should create various incentive policies, such as tax incentives, performance-based support, or cooperative innovation incentives, for enterprises to participate in IEI. On the other hand, a school-enterprise co-governance system for IEI needs to be established. Coal industry associations can be used as industry organizations to play the role of connecting and guiding enterprises to achieve standardized coordination between enterprise resource support and school practice-based teaching, which avoids the lack of overall planning or repeated investment of enterprise resources in practice-based teaching.

Secondly, the cultivation of dual-qualified teachers is the key point of the school's internal governance system building. Because teacher quality plays a moderating role in the process of enterprise resource support for IEI, vocational colleges should pay special attention to the cultivation of dual-qualified teachers. Vocational colleges should adopt a multi-level construction path of short, medium, and long-term exchange, first increase investment in faculty training, and improve faculty technical levels, especially in terms of industrial technologies, practical education integration, and new digital technology application and guidance. Vocational colleges can organize teachers to study and explore in enterprises in batches, and enterprises can send excellent engineers to colleges as “technical experts.” In addition, vocational colleges need to improve the corresponding incentive system to encourage more high-quality teachers to participate in practical teaching, such as performance evaluation standards and corresponding financial subsidies.

Thirdly, it is suggested to establish a talent cultivation and IEI evaluation mechanism. Because the enterprise support for IEI is an open and complex system with many external inputs and internal outputs, on the one hand, it is necessary to evaluate the situation of the quality and depth of enterprise support

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from the level of management and design of the IEI mechanism, and the situation of student practical teaching from the level of classroom teaching. On the other hand, it is necessary to conduct a long-term, objective, and scientific analysis of the data on IEI and talent cultivation, to more intuitively and accurately grasp the state of fit or dynamic fit between the two and provide data support for the sustainable development of IEI and talent cultivation mode.

In conclusion, this paper puts forward the above policy suggestions, but there are still shortcomings in depth and objectivity. In future research, it can be combined with the actual situation of vocational colleges to further verify and explore.

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