School–Enterprise Collaboration Models and the Educational Effectiveness of the Apprenticeship System: An Empirical Study of Higher Vocational Pilot Programmes in Jiangsu Province, China

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Abstract: Amid the restructuring of China's vocational education system, the apprenticeship system promoted nationally in China — a dual-subject arrangement in which schools and enterprises jointly design curricula and deliver instruction (hereafter, China's apprenticeship system) — is moving toward deeper industry–education integration and more mature governance, yet micro-level evidence on how different school–enterprise collaboration models actually pay off remains scarce. Drawing on synergy theory, this paper develops an analytical framework of "collaboration model–mechanism maturity–educational effectiveness" and tests it against 416 valid questionnaires collected from 20 pilot programmes in 15 higher vocational colleges in Jiangsu Province. One-way ANOVA and hierarchical regression are used to compare three collaboration models. Apprentices under the dual-subject deep collaboration model reported the shortest job adaptation time and received the highest competency scores from enterprise mentors, and both gaps are significant against the school-led, enterprise-assisted and the enterprise-led, school-assisted models. The advantage of dual-subject collaboration is positively moderated by the maturity of synergy mechanisms. The enterprise-led model performs better than the school-led one in short-term skill formation but lags behind in systematic cultivation and sustainable development. It is recommended that dual-subject deep collaboration be taken as the basic orientation, that mechanism building serve as the key lever, and that digital governance platforms be used to move the MAS from isolated pilots to institutional consolidation.

Keywords: Modern Apprenticeship System; School–Enterprise Collaboration Model; Educational Effectiveness; Synergy Mechanism Maturity; Higher Vocational Education

1. Introduction

The revision of the Vocational Education Law gave vocational education a clearer type-based positioning, and the MAS has since become a major institutional arrangement through which schools and enterprises jointly cultivate talent. Policy documents issued over the following years kept pushing in the same direction: industrial demand is to be written into the whole process of talent cultivation, the modern vocational education system is to be built at a faster pace, programmes for cultivating on-site engineers are to take apprenticeship as their principal training mode, and digital transformation is to deliver the intelligent upgrading of curricula, textbooks and instructional systems. Read together, these documents signal a shift of emphasis. What matters now is less whether collaboration exists than how deep it runs, how stable its mechanisms are and how well it is governed.

In practice, the MAS has become a main channel through which higher vocational colleges serve regional industrial upgrading and help students move from being "students at school" to "professionals at work" [1]. Pilot outcomes, however, diverge markedly. Some programmes have achieved co-development of curriculum standards, joint delivery of instruction and co-construction of assessment systems, so that apprentices reach the job quickly and settle in without much friction. Others stay at the level of one-way output from schools or one-way absorption by enterprises, with collaboration that remains shallow, curricula that do not match and

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educational results that are unstable. This divergence raises the central question of the paper: do different school–enterprise collaboration models produce differentiated educational effectiveness, and if so, through what mechanism?

Research on the MAS has gone far in explaining its institutional logic, operating pathways and practical forms [2-4], but micro-level quantitative work on the differential effects of collaboration models is still thin [5]. On one hand, most studies rest on institutional evolution, typical cases and summaries of experience, and seldom compare educational outcomes across models. On the other, the importance of school–enterprise collaboration mechanisms is widely acknowledged, yet few studies have put "maturity of the synergy mechanism" to an empirical test as a key condition shaping collaboration outcomes [6]. This paper therefore takes pilot programmes of the MAS in higher vocational colleges in Jiangsu Province as its object, introduces synergy theory and builds an analytical framework of "collaboration model–mechanism maturity–educational effectiveness". The aim is to establish how different collaboration models affect educational effectiveness and to supply empirical grounds for the institutional optimisation that is to follow.

2. Literature Review, Theoretical Basis and Hypotheses

2.1 Literature Review

Three strands of research on the MAS stand out.

The first concerns its institutional content and curricular logic. The MAS is generally treated not as an extension of conventional internship placement but as a training system built on dual school–enterprise cultivation and oriented towards the formation of job competence and occupational dispositions. At the curricular level the decisive issue is coherence among job standards, curriculum standards and training standards, together with deep integration of jobs and curriculum [7]. Constituting an apprenticeship curriculum is itself a negotiated accomplishment rather than a transcription of job tasks, and what learners actually experience in the workplace may diverge from the intended curriculum [8].

The second strand covers modes of school–enterprise cooperation and their differing effects. How far the two parties take part in curriculum development, instructional delivery, mentor allocation and assessment feedback is found to bear directly on the quality of talent cultivation [9]. Where enterprise participation is thin, curriculum content drifts away from real job requirements; where the enterprise dominates, theoretical instruction may be pushed to the margin and students' long-term development capacity suffers [10].

The third strand deals with institutional promotion and practical pathways. Work in this line has examined policy evolution and the attractiveness of apprenticeship, programme design and the division of labour between the two parties [11], and the digital reshaping of apprenticeship arrangements [12], offering useful lenses for understanding how the MAS takes root in local settings.

Three gaps nevertheless remain. First, classifications of collaboration models stay largely qualitative and are not measured quantitatively by depth of participation in such key links as curriculum co-development and joint instructional delivery. Second, educational effectiveness is mostly gauged by indirect proxies such as satisfaction and certificate pass rates rather than by indicators that register the quality of occupational transition, job adaptation time and job competency scores among them. Third, mechanistic accounts of why collaboration models produce different outcomes are still thin, and mechanism maturity has rarely been tested as a conditioning variable.

2.2 Theoretical Basis: The Analytical Fit of Synergy Theory

Synergy theory holds that subsystems within a complex system can produce a whole greater than the sum of its parts through non-linear interaction. Whether such a system settles into a stable and orderly structure depends not only on the presence of the participating actors but also on the order parameters that govern the direction of its evolution.

Applied to the MAS, the theory offers four points of fit.

First, schools and enterprises form the two core subsystems of the apprenticeship cultivation system. Schools carry general foundations, theoretical support and normative cultivation; enterprises carry job skills, work-process knowledge and authentic occupational contexts. How tightly the two are coupled determines the operating state of the whole system.

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Second, school–enterprise collaboration models can be read as the external expression of the system's structural form. By the depth of curriculum standard co-development and joint delivery of instruction, three types can be distinguished: dual-subject deep collaboration, school-led with enterprise assistance, and enterprise-led with school assistance. Dual-subject deep collaboration represents the fullest joint participation of both parties across the entire training process and therefore the highest degree of coupling.

Third, educational effectiveness is the expressed outcome of synergy. In the apprenticeship field synergy is not the cooperative relationship as such; it should show up in the quality of apprentices' occupational transition. Job adaptation time and job competency scores are accordingly taken as the core observed indicators.

Fourth, the maturity of the synergy mechanism works as an important order parameter. Even where both parties nominally participate, collaboration can turn into a formality once process standardisation, responsibility lists, communication mechanisms and assessment feedback are missing. Mechanism maturity may therefore condition how collaboration models translate into effectiveness.

2.3 Hypotheses

On the basis of the above analysis, two hypotheses are advanced.

H1: Different school–enterprise collaboration models differ significantly in the educational effectiveness of the MAS. Relative to the school-led and the enterprise-led models, dual-subject deep collaboration shortens job adaptation time and raises job competency to a greater extent.

H2: The maturity of the synergy mechanism significantly moderates the relationship between collaboration model and educational effectiveness. The more mature the mechanism, the stronger the positive effect of dual-subject deep collaboration.

3. Method

3.1 Sample and Data Collection

Jiangsu Province has a comparatively strong vocational education base and broad coverage of MAS pilots, which makes it highly representative. The study takes pilot programmes of the MAS in higher vocational colleges in Jiangsu as its object and adopts stratified multi-stage sampling. Allowing for institutional nature and programme type, 20 pilot programmes were drawn from 15 higher vocational colleges, covering machinery manufacturing, electronic information and modern services.

The survey ran between September and November 2025, with 500 questionnaires distributed. Responses with abnormal completion times, patterned responding or missing key information were removed, leaving 416 valid questionnaires, which cover both apprentices and enterprise mentors. Job adaptation time is based mainly on apprentice reports, whereas job competency scores were completed by enterprise mentors. The regression analyses use the valid observations that completed the key variables.

3.2 Sample Characteristics

As Table 1 shows, dual-subject deep collaboration accounts for the largest share of the sample, which indicates that some programmes have moved beyond conventional internship cooperation toward deeper collaboration in the course of pilot implementation. The school-led and enterprise-led models nevertheless still claim a substantial proportion, so apprenticeship practice remains characterized by the coexistence of diverse forms.

Table 1. Sample Characteristics

Variable	Category	Frequency(n)	Percentage (%)
Institution type	Public	292	70.2
	Private	124	29.8
Program category	Machinery manufacturing	146	35.1
	Electronic information	94	22.6
	Modern services	76	18.3
	Other	100	24.0
Collaboration model	Dual-subject deep collaboration	188	45.2
	School-led, enterprise-assisted	126	30.3
	Enterprise-led, school-assisted	102	24.5

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3.3 Measures

(1) Independent variable: school–enterprise collaboration model

The collaboration model was not self-reported. It was measured along two dimensions — the degree of participation in curriculum standard co-development and the degree of participation in joint delivery of instruction — each consisting of five items rated on a five-point Likert scale. On the basis of the mean characteristics of the two dimensions, the sample was classified into the three models described above.

(2) Dependent variable: educational effectiveness

Two indicators are used:

Job adaptation time: the number of months an apprentice needs, after entering the position, to be able to complete the main work tasks independently.

Job competency score: a composite score assigned by enterprise mentors across skill operation, theoretical application and occupational dispositions on a ten-point scale, following the practice of assessing vocational competence at the level of instructional sensitivity [13].

(3) Moderating variable: maturity of the synergy mechanism

Drawing on existing work on the internal mechanisms of collaborative cultivation, a measure of synergy mechanism maturity was constructed along two dimensions, process standardisation and clarity of responsibilities, with eight items in total. Cronbach's α was 0.85, indicating good reliability.

(4) Control variables

Institution type and program type were included as controls to reduce the influence of confounding factors

3.4 Descriptive Statistics

Table 2 shows that job adaptation time is shortest and job competency highest under dual-subject deep collaboration, and that synergy mechanism maturity is highest in the same group. High-level collaboration thus appears to come with more standardised mechanism design.

Table 2. Descriptive Statistics for Core Variables

Variable	Dual-subject deep collaboration	School-led, enterprise-assisted	Enterprise-led, school-assisted
Job adaptation time (months)	1.2(0.4)	3.5(1.1)	2.8(0.9)
Job competency score (1–10)	8.9(0.7)	7.2(1.0)	8.1(0.8)
Synergy mechanism maturity	4.2(0.5)	3.1(0.6)	3.5(0.7)

Note. Standard deviations in parentheses.

4. Results

4.1 Differences in Educational Effectiveness across Collaboration Models

To test H1, one-way ANOVA was used to examine differences in educational effectiveness across the three collaboration models.

As Table 3 reports, significant differences emerge across collaboration models in both job adaptation time and job competency scores. Post hoc comparisons point to the following pattern.

In job adaptation time, the dual-subject deep collaboration model clearly outperforms the other two. Apprentices needed on average only 1.2 months to reach a relatively proficient state, against 2.8 months under the enterprise-led, school-assisted model and 3.5 months under the school-led, enterprise-assisted model. Where schools and enterprises are jointly embedded in the whole cultivation process, the discontinuity between curricular learning and job practice is markedly reduced and the occupational transition runs more smoothly.

In job competency scores, the dual-subject model comes first (8.9), significantly above the enterprise-led, school-assisted model (8.1) and the school-led, enterprise-assisted model (7.2). Worth noting is that the enterprise-led, school-assisted model does better than the school-led one in short-term skill formation, which shows a clear advantage for deep enterprise involvement in hands-on job skills. Its overall effect nonetheless stays below that of dual-subject deep collaboration, which suggests that strengthening only the enterprise side cannot substitute for systematic collaboration between the two parties.

H1 is therefore supported.

4.2 Moderating Effect of Synergy Mechanism Maturity

To test H2, hierarchical regression was employed, with the relevant variables mean-centered to reduce the risk of multicollinearity.

(1) Job adaptation time as the dependent variable

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Table 3. Tests of Differences in Educational Effectiveness across Collaboration Models

Dependent variable	Dual-subject deep collaboration	School-led, enterprise-assisted	Enterprise-led, school-assisted	F	P
Job adaptation time (months)	1.2	3.5	2.8	45.23	< 0.001
Job competency score	8.9	7.2	8.1	32.15	< 0.001

Table 4. Hierarchical Regression Results for Job Adaptation Time

Variable	Model 1	Model 2	Model 3
Constant	1.5(0.3)	1.2(0.2)	0.8(0.2)
Institution type (private = 1)	0.4(0.2)	0.3(0.1)	0.2(0.1)
Program category (machinery manufacturing = 1)	0.3(0.1)	0.2(0.1)	0.1(0.1)
School-led, enterprise-assisted	—	2.3***	2.1***
Enterprise-led, school-assisted	—	1.6**	1.4**
Synergy mechanism maturity	—	—	-0.10*
Dual-subject deep collaboration × mechanism maturity	—	—	-0.18*
Adjusted R^2	0.12	0.35	0.42
ΔR^2	—	0.23***	0.07**
F	4.15*	18.32***	15.67***

Note. Standard errors in parentheses. * $p < .05$, ** $p < .01$, *** $p < .001$.

The estimates in Table 4 show that collaboration model still affects job adaptation time significantly once the controls are entered. Adding synergy mechanism maturity and its interaction term improves the explanatory power of the model significantly, and the interaction between dual-subject deep collaboration and mechanism maturity is negative and statistically significant. The more mature the synergy mechanism, therefore, the more pronounced the advantage of the dual-subject model in shortening job adaptation time.

(2) Job competency score as the dependent variable

Table 5. Hierarchical Regression Results for Job Competency Score

Variable	Model 1	Model 2	Model 3 |
Constant	7.5(0.4)	8.9(0.3)	8.5(0.3)
Institution type (private = 1)	-0.3(0.2)	-0.2(0.1)	-0.1(0.1)
Program category (machinery manufacturing = 1)	0.2(0.1)	0.1(0.1)	0.1(0.1)
School-led, enterprise-assisted	—	-1.7***	-1.5***
Enterprise-led, school-assisted	—	-0.8*	-0.6*
Synergy mechanism maturity	—	—	0.20*
Dual-subject deep collaboration × mechanism maturity	—	—	0.21*
Adjusted R^2	0.10	0.32	0.40
ΔR^2	—	0.22***	0.08**
F	3.89*	16.25***	14.33***

Note. Standard errors in parentheses. * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 5 reports the corresponding hierarchical regression with the job competency score as the dependent variable. Model 2 shows that both the school-led, enterprise-assisted model ($b = -1.7$, $p < .001$) and the enterprise-led, school-assisted model ($b = -0.8$, $p < .05$) score significantly below the dual-subject deep collaboration reference group. When synergy mechanism maturity and the interaction term are added in Model 3, the adjusted R^2 rises from 0.32 to 0.40 ($\Delta R^2 = 0.08$, $p < .01$), and the interaction between dual-subject deep collaboration and mechanism maturity is positive and significant ($b = 0.21$, $p < .05$). A pattern consistent with the job adaptation model thus appears: synergy mechanism maturity and its interaction term reach significance when job competency is the dependent variable as well. Dual-subject deep collaboration does not by itself produce highly effective educational outcomes; its advantages are released reliably only where processes are standardised, responsibilities clear, communication smooth and the assessment loop reasonably complete.

H2 is therefore supported.

5 Discussion: How School–Enterprise Collaboration Models Affect Educational Effectiveness

5.1 From One-Way Embedding to Joint Construction: The Structural Advantage of Dual-Subject Deep Collaboration

The results place dual-subject deep collaboration clearly ahead of the other two models on both core indicators. What separates the models, then, is not whether enterprises take part but whether their participation reaches into curriculum standards, the organization of instruction and assessment feedback. In the school-led, enterprise-assisted arrangement, enterprises mainly supply internship places while curriculum development and instruction stay with the school, so apprentices still need a fairly long second round of adaptation after entering the job. Dual-subject deep collaboration does the opposite: real enterprise tasks, job standards and work-process knowledge are built into the curriculum in advance, which shortens the chain between "learning at school" and "working on the job".

5.2 From Short-Term Adaptation to Long-Term Development: Differences in the Logic of Competence Generation

The enterprise-led model outscores the school-led one on job competency, so enterprise leadership does bring something to short-term skill training and hands-on adaptation. That gain, however, lies in the quick shaping of specific job skills rather than in integrated occupational competence, the capacity to transfer theory, or the capacity for sustainable development. Put differently, the enterprise-led model is strong on "knowing how to do it" and weaker on "why it is done this way" and on carrying competence over to more demanding tasks [14]. Judged over a long cultivation cycle, dual-subject deep collaboration keeps the greater institutional advantage. Transitions from school to work are also identity transitions, not merely skill transfers, and identity formation of that kind requires the two learning sites to work in step.

5.3 From Willingness to Cooperate to Institutional Capacity: Why Mechanism Maturity Constitutes a Key Order Parameter

Regression results show that mechanism maturity amplifies the positive effect of dual-subject deep collaboration. Cooperation cannot stop at signing agreements and naming roles; it has to move into institutionalisation, process standardisation and clear allocation of responsibility. Where curriculum development lacks a joint deliberative mechanism, instruction lacks a division of responsibility and assessment lacks data support, a nominally "dual-subject" arrangement can slide into formalistic cooperation. Maturity matters because it hands the two parties rule boundaries, communication channels and shared expectations, which lowers the cost of cooperation and narrows implementation drift.

5.4 New Requirements for Collaborative Apprenticeship Governance in the Digital Context

Vocational education reform has been moving from single pilots towards systemic governance. Industry–education consortiums at the municipal level, on-site engineer training and the digital education agenda all tighten the coupling of vocational education with industry, technology and governance. For the MAS, the value of artificial intelligence and digital platforms lies not in replacing authentic work contexts but in making school–enterprise collaboration visible, traceable and evaluable — documenting joint curriculum development, profiling job tasks, feeding back learning data and coordinating dual mentors, for instance. Digitalisation is thus an amplifier of dual-subject collaboration, not a substitute for the apprenticeship system.

6 Conclusions and Implications

6.1 Conclusions

Drawing on MAS pilot samples from higher vocational colleges in Jiangsu Province, this paper analyses the educational effectiveness of different school–enterprise collaboration models. Three conclusions follow.

First, the collaboration model is a key structural variable in the educational effectiveness of the MAS. Dual-subject deep collaboration significantly outperforms both the school-led and the enterprise-led models on job adaptation time and job competency scores alike, which indicates that deep coupling between the two parties in co-developing curriculum standards and jointly delivering instruction shortens the occupational transition period and strengthens integrated occupational competence.

Second, mechanism maturity is an important moderating variable governing how much effect collaboration models release. The more complete the arrangements — standardised processes, clear responsibilities, smooth

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communication and a closed assessment loop — the more readily the institutional advantages of dual-subject deep collaboration turn into stable educational outcomes; where these are absent, those advantages may come to very little.

Third, the models differ in their orientation of competence generation. The enterprise-led model has advantages in short-term skill formation; the school-led model is more conducive to keeping the curriculum system intact; dual-subject deep collaboration accommodates all three goals of job adaptation, skill improvement and sustainable development at once.

Theoretically, this paper brings synergy theory into research on the MAS and constructs and tests the framework of "collaboration model–mechanism maturity–educational effectiveness", which deepens understanding of how synergy effects take shape in vocational education. Practically, the conclusions offer actionable empirical grounds for higher vocational colleges that seek to optimize apprenticeship training models and improve the quality of pilot programmes.

6.2 Practical Implications

(1) Take dual-subject deep collaboration as the basic orientation and move school–enterprise cooperation from participation to co-governance. Higher vocational colleges should turn enterprises from recipients of interns into co-constructors of the whole cultivation process, encouraging substantive involvement in program design, curriculum standard development, instructional delivery and assessment feedback, and building a full-chain pattern that runs from enrolment through training and assessment to employment. Only in this way can the structural advantages of dual-subject deep collaboration show up in shorter adaptation time and higher job competency.

(2) Use mechanism building and digital governance as dual safeguards to convert willingness to cooperate into sustainable institutional capacity.

This paper confirms that mechanism maturity significantly moderates the effect that collaboration models release. Institutional arrangements should therefore be put in place: joint curriculum development committees, dual-mentor responsibility lists, collaborative deliberation and joint assessment. At the same time, digital platforms for school–enterprise collaboration should be built so that curriculum development, job tasks, student growth and assessment feedback sit in one data chain, which moves collaboration from experience-based to data-based practice. Digital tools are an amplifier of collaboration efficiency, not a substitute for authentic production contexts.

(3) Adopt a differentiated, region-oriented strategy for implementation.

Technology-intensive programmes should pair dual-subject deep collaboration with on-site engineer training and strengthen the coupling of job standards, work-process knowledge and curriculum. Programmes in fields such as modern services may proceed step by step, drawing on municipal industry–education consortiums to pool regional enterprise resources and steering the school-led, enterprise-assisted model towards dual-subject deep collaboration in an orderly way, so that the overall effectiveness of the MAS improves.

6.3 Limitations and Future Research

Several limitations remain and warrant further work. First, the sample is confined to Jiangsu Province, which limits the regional representativeness of the conclusions. Extending the design to regions with different industrial structures and levels of economic development would allow collaboration models to be examined within different regional industrial ecosystems. Second, the cross-sectional design reveals static relationships among variables but cannot capture how the effect of collaboration models unfolds over time; multi-wave longitudinal data would allow the persistence and evolution of synergy effects to be tested. Third, educational effectiveness is measured here by job adaptation time and competency scores, both of which stress the short-term quality of occupational transition. Longer-term indicators such as salary growth, occupational mobility and innovative competence could be incorporated into the framework so that the long-term educational outcomes of the MAS may be assessed more fully. Extensions of this kind would deepen understanding of collaborative cultivation mechanisms and help move the MAS from experiential exploration towards institutional consolidation.

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