Digital Transformation and Vocational Teacher Role Reshaping: Industry Collaboration, AI Application and Workplace-Authentic AI Pedagogy in Liaoning Province

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ABSTRACT:
Purpose: This study develops a mediation framework explaining how institutional digital transformation may reshape vocational teachers' roles in Liaoning Province, China, through industry collaboration and AI application. It responds to a persistent problem in TVET reform: digital platforms, smart classrooms and AI-enabled systems do not automatically change teachers' professional judgement, boundary work or role identity.
Design/methodology/approach: This conceptual paper combines role theory, socio-technical perspectives, teacher digital competence research and recent TVET scholarship. It specifies nine hypotheses and sets out a proposed empirical testing strategy for future survey-based PLS-SEM analysis, while making clear that the present manuscript does not report field data or statistical findings.
Findings: The framework suggests that industry collaboration operates as a workplace-authenticity mechanism and that AI application operates as a pedagogical-intelligence mechanism. Their serial connection explains how authentic enterprise tasks, standards and assessment criteria can be converted into AI-supported diagnosis, simulation, feedback and evaluation. The proposed concept of workplace-authentic AI pedagogy captures this linkage.
Originality/value: The study shifts attention from infrastructure-centred digitalisation to teacher role reconstruction. It theorises digital transformation as a role-structuring condition and positions Liaoning as an industrial and policy setting in which digital governance, school-enterprise collaboration and AI-supported pedagogy intersect..

Keywords: digital transformation; vocational education; TVET; teacher role reshaping; industry collaboration; artificial intelligence; Liaoning Province; conceptual framework.

1. Introduction

Vocational education is increasingly expected to mediate between technological change, labour-market restructuring and the renewal of teaching practice. Digital platforms, intelligent training systems, learning analytics and AI-supported assessment are often introduced as solutions to quality improvement. Yet the unresolved issue is not whether vocational colleges can acquire digital tools, but whether these tools reorganise the professional judgement, boundary work and role identity of teachers.

This issue is especially important because vocational teachers work in a hybrid professional space. They are classroom instructors, curriculum translators, practical-training designers, industry liaisons, workplace-learning mentors and evaluators of occupational competence (Diao & Yang, 2021; Diao et al., 2022; OECD, 2021). Digital transformation therefore affects them not only as technology users but also as professionals whose responsibilities are negotiated across educational, industrial and technological domains.

Liaoning Province offers a theoretically useful setting for this question. Its vocational education digital-campus plan links digital governance and digital teaching capacity to the broader construction of 'Digital Liaoning' and a 'Smart Manufacturing Province' (Liaoning Provincial Department of Education, 2022). More recent provincial measures on industry-education integration enterprises emphasise enterprise participation in talent cultivation, teacher enterprise practice, training-base construction and school-enterprise cooperation (Liaoning Provincial Development and Reform Commission & Liaoning Provincial Department of Education, 2024). Liaoning is therefore not treated here as a local background only; it is used as a regional case in which digital governance, industrial renewal and vocational teacher development converge.

The framework developed in this study is built around two mediating mechanisms. The first is industry collaboration. When digital systems connect curricula, training bases, enterprise projects and student practice, teachers gain access to current occupational standards and workplace tasks. The second is AI application. When teachers use AI for diagnosis, simulation, feedback, resource generation and assessment, their role can move beyond content delivery toward mentoring, design and evidence-informed professional judgement. Figure 1 presents this Liaoning mechanism.

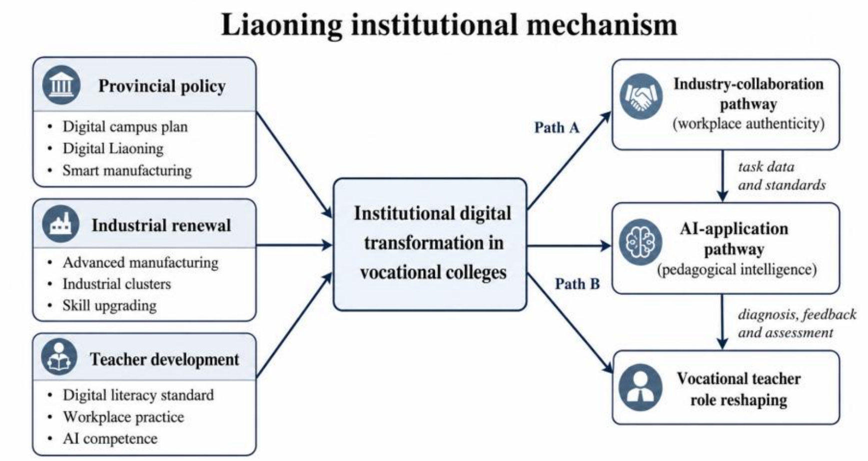

Figure 1. Liaoning mechanism for digital transformation and vocational teacher role reshaping

Note. The upper route represents the industry-collaboration pathway, and the lower route represents the AI-application pathway. Source: Authors' own elaboration based on Liaoning Provincial Department of Education (2022), Liaoning Provincial Development and Reform

Commission and Liaoning Provincial Department of Education (2024), and Ministry of Education of China (2022).

The study addresses three research questions. First, how can digital transformation be theorised as a role-structuring condition in vocational education? Second, how do industry collaboration and AI application mediate the relationship between institutional digital transformation and teacher role reshaping? Third, why does the serial pathway from industry collaboration to AI application matter for workplace-authentic AI pedagogy in TVET? Table 1 defines the four core constructs and clarifies their boundaries.

Table 1. Core constructs and theoretical boundaries

Construct	Definition in this article	Boundary clarification	Key theoretical support
Digital transformation (DT)	Institutional-level integration of digital infrastructure, governance routines, data systems and platform-supported coordination in vocational colleges.	DT is not defined as teachers' personal use of AI tools; it refers to the organisational conditions that structure teaching work.	OECD (2023b, 2025); Xu et al. (2024); Zhong & Juwaheer (2024)
Industry collaboration (IC)	Substantive school-enterprise cooperation in curriculum design, workplace practice, training-base operation, project learning and occupational assessment.	IC is not a symbolic partnership label; it requires repeated knowledge exchange between teachers and enterprise actors.	OECD (2021, 2023a); Liaoning Provincial Development and Reform Commission & Liaoning Provincial Department of Education (2024)
AI application (AIA)	Teacher-practice-level use of AI for learning diagnosis, simulation, adaptive feedback, resource generation, analytics and competence assessment.	AIA is distinguished from DT because it concerns teachers' pedagogical use of AI rather than institutional infrastructure.	Miao & Holmes (2023); UNESCO (2024); Du et al. (2024); Tan et al. (2025)
Teacher role reshaping (TRR)	Changes in teachers' expected responsibilities, enacted practices and professional identity, including movement toward co-designer, mentor, broker and evaluator roles.	TRR is broader than digital competence; it concerns how professional work is reorganised.	Biddle (1986); Diao & Yang (2021); Zhang (2026)

Note. DT = digital transformation; IC = industry collaboration; AIA = AI application; TRR = teacher role reshaping. Source: Authors' synthesis.

The study makes three contributions. First, it extends role theory by explaining teacher role reshaping as a mediated institutional process, rather than a matter of individual digital willingness alone. Second, it connects TVET digital transformation with workplace authenticity and AI-supported pedagogy, thereby specifying mechanisms through which digital systems may become educationally meaningful. Third, it provides a testable mediation framework and empirical strategy for future research in Liaoning and comparable industrial regions.

2. Literature Review and Contextual Background

2.1 Digital transformation in TVET: beyond infrastructure adoption

A recurring limitation in education-technology debates is the tendency to equate digital transformation with the availability of platforms, devices or smart-classroom equipment. In TVET, this view is inadequate because vocational learning is organised around occupational standards, practical tasks, safety requirements and workplace judgement. A digital campus that improves administrative reporting but leaves curriculum design, enterprise cooperation and assessment practice unchanged cannot be considered educationally transformative.

Technology acceptance theory, the theory of planned behaviour and diffusion theory remain useful for explaining why individuals adopt technologies (Ajzen, 1991; Davis, 1989; Rogers, 2003; Venkatesh et al., 2003). However, they explain only part of teacher role reshaping. A teacher may accept a platform without changing what they design, coordinate, judge or justify. For this reason, the present framework uses adoption theories as background and places role theory and socio-technical boundary spanning at the centre of the argument.

Recent TVET scholarship has moved in this direction. Xu et al. (2024) describe vocational education digital transformation as a progressive movement from technological empowerment to educational reconstruction. Yang and Wu (2024) emphasise international cooperation and institutional capacity building in digital TVET, while Zhong and Juwaheer (2024) propose a whole-institution approach that includes leaders, teachers and learners. These studies support the present article's view that teacher role reshaping must be understood as part of a wider digital ecology rather than as an isolated teacher-skills issue.

2.2 Liaoning Province as a policy and industrial setting

The Liaoning case is relevant because it brings together digital governance, industrial renewal and vocational education reform. The provincial digital-campus plan asks vocational colleges to improve digital governance capacity, support high-quality talent cultivation and serve the construction of Digital Liaoning and Smart Manufacturing Province (Liaoning Provincial Department of Education, 2022). The policy does not frame digitalisation as a purely technical agenda; it explicitly links digital campus construction to industrial adaptability and talent development.

The province's industry-education integration enterprise policy adds a second institutional layer. It defines provincial integration enterprises as organisations that deeply participate in vocational education, school-enterprise cooperation, talent cultivation and reform (Liaoning Provincial Development and Reform Commission & Liaoning Provincial Department of Education, 2024). This policy is important for the present framework because it gives industry collaboration an organisational basis. Teachers can reshape their roles only when cooperation with enterprises moves from ad hoc visits to sustained curriculum, assessment and training-base collaboration.

Several studies by Xianghan Zhang and collaborators help contextualise the wider digital-transformation environment. Zhang and Li (2025a) describe smart government as a setting in which data sharing, precise service and government-enterprise interaction support digital capacity building. Their work on organisational resilience further argues that digital transformation enhances adaptive capacity when it becomes embedded in organisational routines (Zhang & Li, 2025b). Lin and Zhang (2025) show how data elements can support industrial upgrading in a manufacturing context. These studies are used as contextual support rather than core TVET evidence: they help explain why digital infrastructure becomes valuable only when connected to organisational capacity, industrial upgrading and practical problem solving.

2.3 Teacher role reshaping and digital competence

Teacher role reshaping refers to changes in the expectations, practices and identity associated with teaching work. Role theory views roles as socially organised patterns of expectation and action (Biddle, 1986). In vocational education, these expectations are shaped by both educational institutions and occupational communities. A teacher may be expected to explain theory, supervise equipment, design projects, maintain industry contact, guide workplace practice and judge whether a student has reached occupational competence. Digital transformation can reconfigure these tasks by changing the evidence, tools and coordination channels available to teachers.

Digital competence research provides an important but incomplete foundation. DigCompEdu conceptualises educators' digital competence across professional engagement, digital resources, teaching and learning, assessment, learner empowerment and learner digital competence (Redecker, 2017). China's teacher digital literacy standard similarly emphasises digital awareness, digital technology knowledge and skills, digital application, social responsibility and professional development (Ministry of Education of China, 2022). Empirical work confirms that TVET teachers' digital competence is influenced by both personal and institutional factors (Xin et al., 2024), and that teachers' digital competence can shape technology acceptance in vocational education (Antonietti et al., 2022).

However, competence does not equal role transformation. Digital competence explains whether teachers can use tools; role reshaping explains whether their responsibilities, authority and professional identity are reorganised by those tools. A teacher may be digitally competent without experiencing role reconstruction; role reshaping occurs only when digital systems change what teachers are expected to design, coordinate, judge and justify. Roll and Ifenthaler (2021) show that vocational teachers require multidisciplinary digital competencies, while Diao and Yang (2021) argue for assessing TVET teaching ability through multiple roles. Zhang's (2026) study of sustainability-oriented teaching in vocational and applied higher education is especially relevant because it links practice-based, socially meaningful teaching with student value outcomes through motivation and learning commitment. This supports the argument that teacher role reshaping is better judged not by tool use alone, but by teachers' capacity to design meaningful, practice-oriented and socially relevant learning experiences.

2.4 Industry collaboration as a boundary-spanning mechanism

Industry collaboration is one of the defining conditions of credible vocational education. It enables programmes to remain connected to changing occupational standards, equipment, production processes and workplace cultures. For teachers, collaboration with enterprises supplies the authentic tasks and assessment criteria that cannot be generated by classroom platforms alone. OECD (2021, 2023a) emphasises the importance of teachers and leaders in VET systems that remain responsive to labour-market change, while Liaoning's industry-education integration policy provides a provincial mechanism for institutionalising such collaboration.

The concept of boundary spanning is useful here. Vocational teachers cross boundaries when they translate enterprise requirements into curriculum units, transform workplace problems into project tasks and align classroom assessment with occupational standards. This work is not merely administrative. It can alter the teacher's role from content transmitter to curriculum co-designer, workplace-learning broker and evaluator of practical competence. Industry collaboration therefore mediates the effect of digital transformation because digital platforms and data systems are educationally consequential only when they support these boundary-spanning activities.

2.5 AI application as a pedagogical-intelligence mechanism

AI application creates a second pathway from institutional digital transformation to teacher role reshaping. In education, AI can support diagnosis, resource generation, adaptive feedback, simulation, tutoring, analytics and assessment (Miao & Holmes, 2023; UNESCO, 2024). The UNESCO AI competency framework for teachers places AI within a human-centred and ethical professional framework, including AI foundations, AI pedagogy and AI for professional learning (UNESCO, 2024). These dimensions are important because they prevent AI application from being reduced to automated content production.

Empirical studies also suggest that AI can affect teachers' professional agency in ambivalent ways. Du et al. (2024) find that AI literacy is associated with teachers' self-efficacy, awareness of AI ethics and behavioural intention to learn AI. Duan and Zhao (2024) show that AI-powered applications can influence teachers' autonomy, professional development and digital burnout. Tan et al. (2025) likewise conclude that AI in teaching and teacher professional development requires a stronger connection between available AI tools and teachers' professional learning needs. These findings support the present article's caution: AI may expand professional judgement when teachers use it responsibly, but it may also increase workload or dependence if it is implemented without pedagogical purpose and ethical safeguards.

In vocational education, AI application becomes most valuable when it is connected to authentic occupational content. AI-generated cases, virtual simulations and adaptive assessment can support role reshaping only if they reflect current industry tasks, safety rules, quality standards and competence expectations. This is why the serial pathway from industry collaboration to AI application is theoretically important. Industry collaboration supplies workplace authenticity; AI application translates that authenticity into scalable pedagogical intelligence.

2.6 Literature gaps and contribution positioning

Table 2 consolidates the literature gaps that motivate the framework. The gaps do not imply that prior research is weak; rather, they indicate where existing conversations remain fragmented. Digital TVET studies often focus on infrastructure, teacher competence studies often focus on skills, and AI-in-education studies often focus on tools. The present article connects these strands by treating teacher role reshaping as a mediated role-reconstruction process.

Table 2. Literature gaps and contribution positioning

Research stream	What is well established	Remaining gap	Contribution of this article
TVET digital transformation	Digitalisation can support resource sharing, digital governance and high-quality vocational education (OECD, 2025; Xu et al., 2024; Yang & Wu, 2024).	Teacher roles are often implied but not theorised as a central outcome.	The article treats digital transformation as a role-structuring condition.

Research stream	What is well established	Remaining gap	Contribution of this article
Teacher digital competence	Digital competence frameworks define important skills and standards (Redecker, 2017; Ministry of Education of China, 2022; Xin et al., 2024).	Competence research does not fully explain how professional responsibilities and identities change.	The article distinguishes digital competence from role reshaping.
Industry collaboration	School-enterprise collaboration is central to VET adaptability (OECD, 2021, 2023a).	Collaboration is rarely modelled as a mediator between digital transformation and teacher role change.	The article defines industry collaboration as a workplace-authenticity mechanism.
AI in teaching	AI literacy, AI ethics and AI-supported professional learning are increasingly emphasised (Du et al., 2024; Tan et al., 2025; UNESCO, 2024).	AI application is often separated from industry authenticity in vocational settings.	The article defines AI application as a pedagogical-intelligence mechanism linked to authentic occupational tasks.
Regional policy studies	Liaoning policy connects digital campus construction with smart manufacturing and industry-education integration.	Regional policies are rarely used to theorise mediated teacher role reconstruction.	The article positions Liaoning as a policy-relevant theoretical setting.

Note. Source: Authors' synthesis of the cited literature.

3. Theoretical Framework and Hypothesis Development

3.1 Theoretical position: role theory and socio-technical boundary spanning

The framework is grounded in role theory and a socio-technical understanding of digital transformation. Role theory explains why teacher work cannot be reduced to a list of competencies. A role contains expectations, norms, authority, responsibility and enacted behaviour (Biddle, 1986). Socio-technical analysis adds that these expectations are shaped by the interaction between technologies, organisational routines and social arrangements. Digital transformation therefore matters because it changes not only tools, but also the coordination routines and evidence systems through which teachers enact professional responsibilities.

This theoretical position is compatible with, but broader than, adoption models. TAM, TPB, UTAUT and diffusion theory explain important antecedents of technology use (Ajzen, 1991; Davis, 1989; Rogers, 2003; Venkatesh et al., 2003). TPACK and Shulman's knowledge-base theory also help clarify how technological, pedagogical and content knowledge interact (Mishra & Koehler, 2006; Shulman, 1986). Yet the present article focuses on a different outcome: role reshaping. The proposed model therefore asks how digital transformation changes what vocational teachers are expected to do, how they coordinate with enterprises and how they exercise judgement when AI becomes part of teaching practice.

A key construct boundary is necessary. Digital transformation is conceptualised at the institutional level as infrastructure, governance, platform integration and coordination capacity. AI application is conceptualised at the teacher-practice level as the purposeful use of AI for diagnosis, simulation, feedback, resource generation and assessment. Industry collaboration is conceptualised as substantive school-enterprise cooperation rather than occasional contact. Teacher role reshaping is conceptualised as a change in role expectations, enacted practices and professional identity rather than as a simple increase in digital skill.

3.2 Digital transformation and teacher role reshaping

Digital transformation can reshape teacher roles because it changes resources, evidence and coordination routines. Digital platforms make curriculum resources more shareable, learning analytics make student progress more visible, and smart training systems make practical tasks more traceable. These changes can expand teachers' responsibilities from delivering content to designing learning pathways, interpreting data, coordinating practice and making competence-based judgements. In this sense, digital transformation is a role-structuring condition.

The expected relationship is positive but not automatic. Digitalisation may also narrow discretion if it is implemented primarily as surveillance, reporting or procedural compliance. For this reason, the framework does not assume a simple technological determinism. It proposes a direct association while also theorising mediation through industry collaboration and AI application.

H1. Institutional digital transformation in vocational colleges is positively associated with vocational teacher role reshaping.

3.3 The mediating role of industry collaboration

Digital transformation can strengthen industry collaboration by making cooperation easier to organise, record and evaluate. Digital platforms can host co-developed teaching resources, coordinate enterprise projects, document student practice and support communication between teachers and enterprise mentors. In Liaoning, this mechanism is particularly plausible because policy encourages enterprises to participate in vocational education reform and practical training.

Industry collaboration can then reshape teacher roles. Teachers who engage in enterprise practice or co-design modules with industry experts are more likely to become translators of occupational standards, designers of authentic tasks and brokers between school and workplace. This mediating pathway is therefore conceptualised as a workplace-authenticity mechanism.

H2. Institutional digital transformation is positively associated with industry collaboration in vocational education.

H3. Industry collaboration is positively associated with vocational teacher role reshaping.

H4. Industry collaboration mediates the relationship between institutional digital transformation and vocational teacher role reshaping.

3.4 The mediating role of AI application

Digital transformation also makes AI application more likely. Colleges with stronger digital infrastructure, data governance and platform integration are better placed to deploy AI-enabled tools for learning diagnosis, simulation, feedback and assessment. However, AI application remains a teacher-practice construct: it concerns how teachers use AI to make pedagogical decisions, not whether the college has purchased an AI product.

AI application may reshape teachers' roles by shifting professional work from one-way explanation to diagnosis, design, mentoring and evidence-informed evaluation. It can also generate new ethical responsibilities, including transparency, privacy protection and critical interpretation of algorithmic output (European Commission, 2022; UNESCO, 2024). When AI is used in this manner, teachers become professional interpreters of AI-supported evidence rather than passive operators of automated systems.

H5. Institutional digital transformation is positively associated with teachers' AI application.

H6. Teachers' AI application is positively associated with vocational teacher role reshaping.

H7. Teachers' AI application mediates the relationship between institutional digital transformation and vocational teacher role reshaping.

3.5 The serial mechanism linking industry collaboration and AI application

The serial pathway is the most distinctive part of the framework. The proposed order does not imply that AI tools cannot stimulate external collaboration. Rather, it follows a vocational-education logic: AI-supported teaching becomes occupationally credible only when it is informed by authentic tasks, workplace standards and assessment criteria supplied through industry collaboration.

Industry collaboration can therefore enhance AI application by supplying real cases, current technical standards, enterprise projects and competence criteria. AI application then translates these inputs into scalable learning diagnosis, task simulation, feedback and assessment. The serial pathway is not merely a sequence of institutional conditions; it describes how workplace authenticity becomes pedagogical intelligence when enterprise tasks and standards are converted into AI-supported teaching practice.

H8. Industry collaboration is positively associated with teachers' AI application.

H9. Institutional digital transformation has a serial indirect effect on vocational teacher role reshaping through industry collaboration and teachers' AI application. Figure 2 integrates the direct, parallel and serial mediation paths, and Table 3 consolidates the hypothesised relationships.

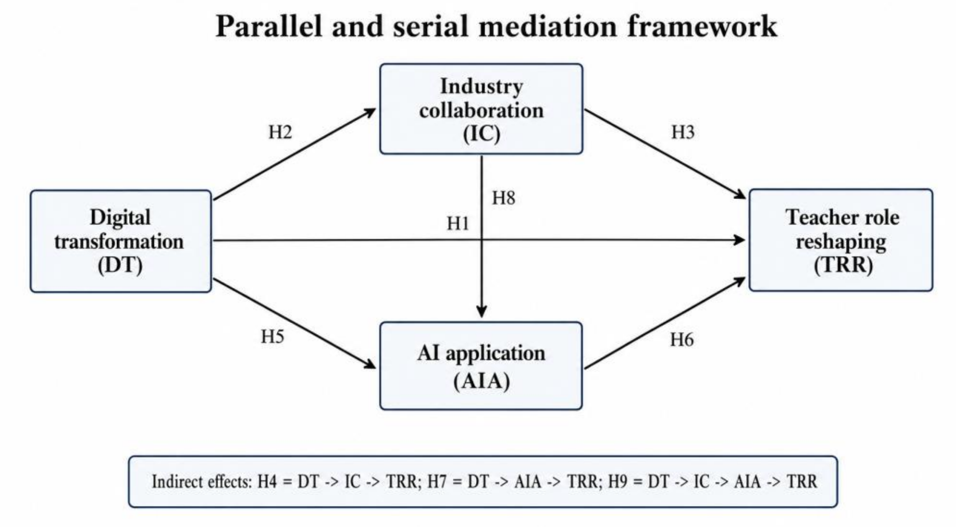

Figure 2. Conceptual mediation model

Note. DT = institutional digital transformation; IC = industry collaboration; AIA = AI application; TRR = teacher role reshaping. H4, H7 and H9 refer to indirect effects. Source: Authors' own elaboration.

Table 3. Hypotheses and directional logic

Hypothesis	Path	Theoretical logic
H1	DT -> TRR	Digital transformation restructures resources, evidence systems and coordination routines that shape teacher work.
H2	DT -> IC	Digital platforms and governance routines make school-enterprise coordination easier to organise and document.
H3	IC -> TRR	Industry collaboration expands teachers' boundary-spanning, curriculum-design and competence-evaluation roles.
H4	DT -> IC -> TRR	Industry collaboration mediates the link between institutional digitalisation and role reshaping.
H5	DT -> AIA	Institutional digital maturity supports the pedagogical use of AI tools.
H6	AIA -> TRR	AI application shifts teacher work toward diagnosis, mentoring, simulation and evidence-based judgement.
H7	DT -> AIA -> TRR	AI application mediates the link between digital transformation and role reshaping.
H8	IC -> AIA	Industry collaboration supplies authentic tasks and standards that make AI-supported teaching occupationally credible.
H9	DT -> IC -> AIA -> TRR	The serial pathway represents workplace-authentic AI pedagogy.

Note. DT = institutional digital transformation; IC = industry collaboration; AIA = AI application; TRR = teacher role reshaping.

4. Proposed Empirical Testing Strategy

4.1 Research design and scope

This study is a conceptual paper with a proposed empirical testing strategy. The strategy is included to make the framework testable and transparent, not to imply that field data have already been collected. Future empirical work can examine teachers' perceptions of institutional digital transformation, industry collaboration, AI application and role reshaping across vocational colleges in Liaoning Province.

A survey design is appropriate for an initial test because the model contains multiple latent constructs and parallel and serial mediation paths. A later mixed-methods design would strengthen the study further by using interviews to explain how teachers experience role conflict, enterprise cooperation and AI-supported judgement in concrete teaching situations. Table 4 summarises a fieldwork protocol that would allow future research to move from the present conceptual framework to a full empirical article.

Table 4. Recommended sampling and fieldwork protocol

Component	Recommended design	Rationale
Population	Teachers in higher vocational colleges and eligible secondary vocational schools in Liaoning Province.	The population matches the regional and institutional scope of the framework.
Geographic	At least six to eight cities, including both major	Multi-city sampling reduces the

Component	Recommended design	Rationale
coverage	industrial centres and non-core localities.	risk of single-campus or single-city bias.
School and discipline strata	Include programmes in intelligent manufacturing, information technology, transportation, health services, modern services and agriculture where available.	Different occupational fields vary in digital maturity and enterprise collaboration.
Minimum sample	A minimum of 350 valid responses; 450-500 responses if subgroup analysis is planned.	This supports stable PLS-SEM estimation and mediation analysis.
Data sources	Teacher survey as the main source; optional administrator data on digital infrastructure and school-enterprise partnerships.	Multi-source information can reduce self-report limitations.
Timing	A two-wave survey is preferred: DT and IC at Time 1; AIA and TRR at Time 2.	Temporal separation helps address common method bias.
Controls	Gender, age, teaching experience, title, education level, school type, professional field, dual-qualified status, enterprise experience and AI training.	Control variables capture alternative explanations of teacher role change.

Note. The table is a proposed empirical protocol. It does not report completed fieldwork.

4.2 Measurement strategy

Measurement needs to preserve the conceptual boundaries established in Table 1. Digital transformation items measure perceived institutional infrastructure, governance and coordination routines. Industry collaboration items measure substantive school-enterprise cooperation. AI application items measure teachers' pedagogical use of AI. Teacher role reshaping items measure changes in professional responsibilities and role identity. Table 5 reports a concise scale blueprint, while Appendix Table A1 provides fuller item wording for future pilot testing.

The instrument can be developed in English and Chinese through translation and back-translation. Expert review by TVET researchers, vocational teachers and enterprise mentors can assess content validity. Cognitive interviews can check whether teachers distinguish digital transformation from AI application and role reshaping from digital competence. A pilot test with 30-50 teachers can identify ambiguous items before the main survey.

Table 5. Measurement blueprint

Construct	Indicative dimensions	Example item logic	Source logic
Digital transformation	Digital infrastructure; platform integration; data governance; institutional coordination.	My college uses digital systems to coordinate teaching, assessment and programme management.	OECD (2023b, 2025); Xu et al. (2024); Zhong & Juwaheer (2024)
Industry collaboration	Curriculum co-design; enterprise practice; training-base cooperation; occupational assessment.	Enterprise partners provide input into curriculum, practical training or student assessment.	OECD (2021, 2023a); Liaoning provincial policy (2024)
AI application	Diagnosis; simulation; adaptive feedback; resource generation; AI-supported assessment.	I use AI-supported tools to diagnose learning difficulties or provide feedback in practical training.	Miao & Holmes (2023); UNESCO (2024); Du et al. (2024); Tan et al. (2025)
Teacher role reshaping	Curriculum co-designer; workplace-learning broker; AI-enabled mentor; evidence-informed evaluator.	My role increasingly involves designing authentic learning tasks with workplace or digital evidence.	Biddle (1986); Diao & Yang (2021); Diao et al. (2022); Zhang (2026)

Note. Full item wording appears in Appendix Table A1. Items require expert review, cognitive interviewing and pilot testing before formal use.

4.3 Ethics and data-quality safeguards

Future empirical testing will require careful ethics and data-quality safeguards because the constructs concern institutional practices, teachers' work and AI use. Anonymity is essential, especially where teachers are asked to evaluate their colleges' digital transformation or school-enterprise collaboration. Common method bias can be addressed through procedural separation, clear instructions, varied item wording and statistical diagnostics rather than through a single post-hoc test. Table 6 identifies safeguards that can be built into future research.

Table 6. Ethics and data-quality safeguards

Risk	Procedural response	Statistical or reporting response
Social desirability	Use anonymous questionnaires and avoid evaluative wording that implies a correct answer.	Report scale reliability and examine response patterns.
Common method bias	Separate sections, vary item anchors, use time-lagged collection when feasible.	Use full-collinearity VIF and marker-variable checks; treat Harman's test only as supplementary (Kock, 2015; Podsakoff et al., 2012).
Construct overlap	Keep DT, IC, AIA and TRR items conceptually distinct during item design.	Assess discriminant validity through HTMT and cross-loadings (Henseler et al., 2015).

Risk	Procedural response	Statistical or reporting response
AI ethics concerns	Avoid collecting sensitive student data through the survey; ask about teacher-level use and perceptions.	Report AI-related limitations and interpret AI use in line with ethical guidance (European Commission, 2022; UNESCO, 2024).
Institutional sensitivity	Use aggregate reporting by region or school type rather than naming institutions.	Provide transparent data availability and ethics statements.

Note. The safeguards are designed for future empirical testing of the framework

4.4 Analytical procedure

PLS-SEM is suitable for an initial test of the model because the framework contains multiple mediation paths, the theory is still developing in the Liaoning TVET context and non-normal survey data may be expected. The approach is also consistent with prediction-oriented theory extension (Hair et al., 2022). If the data satisfy distributional assumptions and sample-size requirements, a covariance-based SEM robustness check can be added to examine whether the path structure remains stable.

Figure 3 presents the proposed workflow. Table 7 summarises the core reporting criteria. The workflow is explicit because mediation claims are often weakened by insufficient reporting of measurement validity, collinearity, indirect effects and alternative models. A credible empirical test would report both the measurement model and the structural model before interpreting the hypothesised mediating mechanisms. In particular, HTMT, full-collinearity diagnostics and common-method safeguards are interpretive preconditions rather than optional appendices (Henseler et al., 2015; Kock, 2015; Podsakoff et al., 2012).

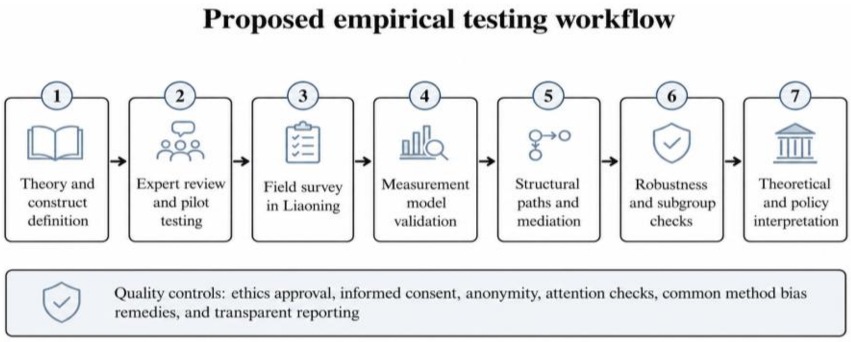

Figure 3. Proposed empirical testing workflow

Note. The workflow is designed for future survey-based testing and can be extended with qualitative interviews or administrative data. Source: Authors' own elaboration.

Table 7. PLS-SEM assessment and reporting criteria

Step	Indicators to report	Interpretive standard
Item quality	Outer loadings; item wording; deletion rationale.	Prefer loadings above .70; retain theoretically essential items only with justification.
Reliability	Cronbach's alpha, rho_A and composite reliability.	Values between .70 and .95 are generally acceptable (Hair et al., 2022).

Step	Indicators to report	Interpretive standard
Convergent validity	Average variance extracted (AVE).	AVE normally exceeds .50.
Discriminant validity	HTMT confidence intervals; cross-loadings where useful.	HTMT below .85 or .90 depending on construct similarity (Henseler et al., 2015).
Collinearity	Inner VIF and full-collinearity VIF.	Values below 3.3 or 5.0 depending on criterion and context (Kock, 2015).
Structural paths	Beta, t-value, p-value, confidence interval and effect size f2.	Report both statistical significance and substantive effect size.
Mediation	Specific indirect effects with 5,000 or 10,000 bootstrap resamples.	Indirect effects are interpreted through confidence intervals, not only p-values.
Prediction and robustness	R2, adjusted R2, Q2, PLSpredict, alternative models and subgroup checks.	Robustness strengthens theoretical credibility and guards against overinterpretation.

Note. These criteria are proposed for future empirical testing; no statistical results are claimed in this conceptual article.

5. Discussion

5.1 Theoretical implications

The framework offers three theoretical implications. First, it reframes digital transformation as a role-structuring condition. Digital transformation is often discussed as infrastructure, platform use or institutional modernisation. This study argues that its educational significance lies in whether it reorganises teachers' professional work. When digital systems alter evidence, coordination and judgement, they may reshape teachers' roles; when they remain peripheral to curriculum and workplace learning, they are unlikely to do so.

Second, the framework defines industry collaboration as a workplace-authenticity mechanism. This mechanism is especially important in vocational education because students' learning must remain linked to occupational standards and practical tasks. Digital platforms alone cannot guarantee that connection. Teachers need sustained collaboration with enterprises in order to translate workplace changes into curriculum, projects and assessment. In this sense, teacher role reshaping is inseparable from boundary-spanning work.

Third, the framework defines AI application as a pedagogical-intelligence mechanism. AI becomes relevant to teacher role reshaping when it supports diagnosis, feedback, simulation and assessment judgement. It is not the presence of AI tools that matters most, but the way teachers interpret and use AI-supported evidence. The serial pathway further advances the concept of workplace-authentic AI pedagogy: AI-supported teaching in TVET is most credible when it is grounded in real industry tasks, enterprise standards and occupational judgement. Table 8 summarises these theoretical contributions.

Table 8. Mechanism-based theoretical contribution

Conceptual move	Mechanism	Contribution to TVET research
From infrastructure to role structure	Digital transformation changes evidence, resources and coordination routines.	Explains why technology adoption does not automatically produce professional transformation.
From partnership label to workplace authenticity	Industry collaboration supplies real tasks, standards and assessment criteria.	Clarifies how school-enterprise cooperation can mediate teacher role change.
From AI tool use to pedagogical intelligence	AI application supports diagnosis, simulation, feedback and evidence-informed judgement.	Links AI in education to teachers' professional agency rather than automation alone.
From parallel mediation to serial mediation	Industry collaboration informs AI application, which then supports teacher role reshaping.	Introduces the concept of workplace-authentic AI pedagogy.

Note. Source: Authors' synthesis.

5.2 Practical implications for Liaoning vocational colleges

The framework has practical implications for vocational colleges, provincial education authorities, enterprises and teachers. First, vocational colleges need to connect digital campus construction with curriculum renewal and teacher development. Digital platforms are unlikely to reshape teaching roles if they are managed only by information-technology departments. Colleges require cross-functional teams that include teachers, enterprise mentors, curriculum experts, data analysts and administrators.

Second, industry collaboration needs to become more pedagogically substantive. School-enterprise cooperation remains weak when it is limited to ceremonial agreements, internship placement or occasional lectures. It becomes pedagogically substantive when organised around co-designed modules, enterprise problem banks, workplace-assessment rubrics, joint training-base governance and teacher enterprise practice. These activities turn industry collaboration into role-expanding professional learning.

Third, AI application requires careful professional governance. Teachers need training not only in prompts or software operation but also in AI ethics, data interpretation, task design and the limits of algorithmic feedback. The European Commission (2022), Miao and Holmes (2023) and UNESCO (2024) all emphasise that AI in education must remain human-centred and ethically governed. Figure 4 translates the framework into a role-development matrix. The lower-right quadrant, labelled tool-intensive adapter, is a risk state rather than an ideal outcome: it indicates high AI use without sufficient workplace authenticity.

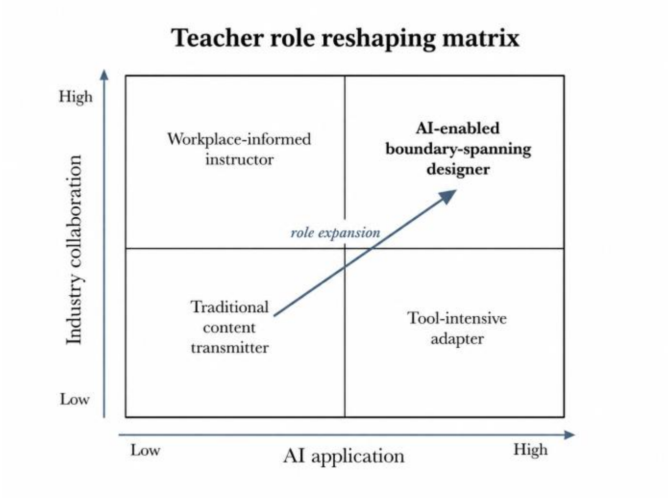

Figure 4. Teacher role reshaping matrix based on industry collaboration and AI application

Note. The desired direction is toward the upper-right quadrant, where workplace authenticity and AI-supported pedagogical intelligence are both present. Source: Authors' own elaboration.

Table 9 turns the discussion into an action matrix for Liaoning's vocational education stakeholders. The table is not a policy checklist; rather, it identifies the institutional conditions most likely to move teachers toward the upper-right quadrant of Figure 4.

Table 9. Action matrix for Liaoning vocational education stakeholders

Stakeholder	**Priority action**	**Expected role effect for teachers**
Provincial education authorities	Align digital-campus evaluation with teacher role development, enterprise collaboration and AI ethics.	Reduces the risk that digitalisation becomes a reporting exercise.
Vocational colleges	Create cross-functional digital teaching support centres that include technical, pedagogical and industry expertise.	Supports teachers as designers and interpreters rather than isolated tool users.
Enterprises	Provide authentic tasks, standards, equipment scenarios and workplace mentors for curriculum and assessment design.	Strengthens teachers' boundary-spanning and curriculum co-design roles.
Teacher development centres	Offer AI pedagogy training connected to specific professional fields and practical-training scenarios.	Moves AI use from generic tool operation to pedagogical judgement.
Programme teams	Build modular repositories of enterprise cases, AI-supported simulations and competence rubrics.	Makes workplace-authentic AI pedagogy operational at course level.
Individual teachers	Develop reflective routines for interpreting AI feedback, student data and enterprise requirements.	Strengthens professional agency and evidence-informed evaluation.

Note. The matrix is designed for conceptual and practical use; empirical validation requires field data.

5.3 Limitations and future research

This study has limitations that are typical of conceptual framework papers. It does not report field data, statistical paths or empirical findings. The proposed relationships therefore require testing with survey, interview and possibly administrative data. The use of Liaoning as a single regional setting is theoretically purposeful, but future research can compare Liaoning with provinces that have different industrial structures or levels of digital education maturity.

Future studies can strengthen the framework in several ways. A longitudinal design can examine whether digital transformation precedes role reshaping over time. Multi-source data can combine teacher perceptions with institutional records of digital systems and school-enterprise cooperation. Qualitative interviews can reveal how teachers experience role tension, workload, professional agency and AI ethics in practice. Comparative studies can also test whether the serial pathway is stronger in programmes with higher industry dependence, such as intelligent manufacturing, transportation, equipment engineering or digital services.

6. Conclusion

Digital transformation is often discussed as a technical or administrative reform, but its deeper significance in vocational education lies in whether it reshapes the work of teachers. This study has developed a mediation framework explaining how institutional digital transformation may affect vocational teacher role reshaping through industry collaboration and AI application in Liaoning Province. Industry collaboration provides workplace authenticity; AI application provides pedagogical intelligence. Their serial connection explains how workplace-authentic AI pedagogy can emerge when enterprise tasks, standards and assessment criteria are translated into AI-supported diagnosis, simulation, feedback and evaluation.

The framework cautions against both technological determinism and symbolic collaboration. Digital platforms cannot reshape teacher roles if they remain disconnected from occupational tasks, and AI cannot produce vocationally meaningful learning if it is detached from industry standards and teacher judgement. The most promising direction is to build institutional arrangements in which teachers, enterprises and AI-supported systems jointly contribute to authentic, evidence-informed and ethically governed vocational learning.

Declarations

Data availability: No new empirical data were generated or analysed in this conceptual study.

Ethics statement: This manuscript does not involve human participants, human data or field experimentation. Ethics approval was therefore not required for the present conceptual study. Any future survey based on the proposed framework will require informed consent and institutional ethics review where applicable.

Conflict of interest: The authors declare no conflict of interest.

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