Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Adaptive Pathways for Industry–Education Integration in Private Vocational Colleges in the Era of New Quality Productivity

Wenya Wu
INTI international university
Niaz ali
niaz.ali@newinti.edu.my

INTI international university

Research Article

Keywords: Industry–education integration, perceived ease of use, PLS-SEM, vocational education, TAM

Posted Date: May 22nd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9384135/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Adaptive Pathways for Industry–Education Integration in Private Vocational Colleges in the Era of New Quality Productivity

First author:

Wu Wenya

1.INTI International University

2. Xingtai Vocational College of Applied Technology, Xingtai, Hebei 054700, China

Email: I25030625@student.newinti.edu.my

ORCID: 0009-0007-0051-9274

Corresponding author:

Niaz Ali

Email niaz.ali@newinti.edu.my

INTI International University Malaysia

ORCID orcid logo https://orcid.org/

0000-0002-5142-1863

Abstract

Amid the rapid advancement of new quality productivity and digital transformation, private vocational colleges face persistent challenges in achieving effective industry–education integration. Despite policy emphasis, the imbalance between institutional engagement and enterprise participation suggests a limited understanding of the underlying mechanisms shaping integration outcomes. This study addresses this gap by examining the influence of a "four-dimensional integration pathway" (goal reshaping, process restructuring, platform reconstruction, and evaluation reorganization) on the depth of industry–education integration. It further investigates the mediating roles of perceived ease of use and perceived usefulness within the Technology Acceptance Model (TAM) in a mandatory usage context. Data were collected from 227 respondents, including administrators, teachers, and enterprise personnel, using a structured questionnaire based on a five-point Likert scale. A multistage cluster stratified sampling technique was applied. The data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM) via SmartPLS 4.0, incorporating reliability, validity, and mediation analyses with bootstrap resampling (5,000 samples). The findings indicate that the four-dimensional integration pathway significantly influences both perceived ease of use and perceived usefulness, as well as

the depth of industry–education integration. However, only perceived ease of use demonstrates a significant mediating effect ($\beta = 0.127$, $p < .01$), while perceived usefulness is not significant. This suggests that ease of use plays a more critical role than perceived usefulness in contexts of constrained or mandatory technology adoption. The study contributes to extending TAM by highlighting its boundary conditions and offers practical implications for reducing participation barriers. Limitations include the cross-sectional design and limited generalizability.

Keywords: Industry–education integration; perceived ease of use; PLS-SEM; vocational education; TAM

1. Introduction (Rewritten – Scopus & APA 7th Standard)

The rapid advancement of new quality productivity, driven by emerging technologies and industrial transformation, is fundamentally reshaping the demand for technical and skilled labor (Guo, Wang, Zhou, & Luo, 2026). This transformation is characterized by increasing requirements for interdisciplinary competencies, digital literacy, and sustainable skillsets, particularly in fields such as artificial intelligence, green manufacturing, and the industrial Internet (Jacobs, & Goedhals-Gerber, 2026). At the same time, digital transformation is redefining the structure and delivery of vocational education by altering teaching environments, resource configurations, and institutional governance models (Ta, & Pham, 2026). Within this evolving landscape, private vocational colleges—given their close alignment with industry—are under increasing pressure to develop adaptive talent cultivation systems capable of responding to rapidly changing labor market demands.

Despite the growing emphasis on industry–education integration as a strategic priority, existing research has predominantly focused on macro-level policy analysis, descriptive models, or static evaluations of coordination between education and industry (Uzule, 2026). Such approaches often overlook the dynamic and process-oriented nature of integration, particularly the mechanisms through which stakeholders adapt to institutional and technological changes. In the context of private vocational colleges, the widely observed phenomenon of "active institutional engagement but limited enterprise participation" reflects deeper structural and behavioral challenges. Specifically, the lack of adaptive responses among stakeholders—shaped by considerations of cost, effort, and perceived value—has constrained the effectiveness of integration initiatives (Weishaupt, Kuhn, Baatz, & Vafeidis, 2026). This suggests that the "black box" of psychological perception remains insufficiently explored in the literature.

To address this gap, the present study proposes and empirically tests an adaptive model of industry–education integration within the context of new quality productivity and digital transformation. The study is guided by the central research question: *Through what mechanisms does the industry–education integration model influence stakeholder behavior and ultimately enhance the depth of integration in private vocational colleges?* In response, this research develops a conceptual framework that integrates ecosystem theory with the Technology Acceptance Model (TAM) (Davis, 1989), conceptualized as a "two-wheel drive and four-dimensional adaptation"

model. The framework emphasizes the role of goal reshaping, process restructuring, platform reconstruction, and evaluation reorganization as key drivers of integration outcomes, while examining the mediating effects of perceived usefulness and perceived ease of use (Rawashdeh, 2025).

Methodologically, this study employs Partial Least Squares Structural Equation Modeling (PLS-SEM) to test the proposed relationships using empirical data collected from multiple stakeholder groups. By incorporating both formative and reflective constructs, the study provides a nuanced understanding of how structural interventions influence psychological perceptions and behavioral outcomes (i.e., Daumiller, & Meyer, 2025).

This research contributes to literature in several ways. First, it advances theoretical understanding by integrating macro-level ecosystem perspectives with micro-level technology acceptance mechanisms (i.e., Steinhauser, 2025). Second, it extends the applicability of TAM by examining its explanatory power in a context characterized by partially mandatory technology use (i.e., Badda, 2025). Third, it offers practical insights for educational leaders and policymakers by highlighting the importance of reducing participation barriers and enhancing user experience, thereby facilitating a shift from traditional management-oriented approaches to perception-driven integration strategies (i.e., Ferreira, Tukaiev, & Lopes, 2026). Collectively, these contributions provide a foundation for promoting the sustainable and high-quality development of industry–education integration in vocational education.

Literature Review

Existing literature has provided a substantial foundation for understanding industry–education integration and vocational education reform; however, several critical theoretical gaps remain. First, in the context of new-quality productive forces, prior studies generally acknowledge increased demands for digital literacy, innovation capability, and green skills among technical and vocational graduates. Nevertheless, most research remains descriptive, focusing on skill demand identification rather than explaining how vocational training systems dynamically adapt to evolving industrial requirements (i.e., Düzgünçınar, 2025; Huang, 2025). As a result, the internal mechanism of adaptive transformation remains under-theorized.

Second, within the domain of digital transformation and industry–education integration, existing research has highlighted emerging enabling infrastructures such as virtual simulation platforms and industrial internet ecosystems. However, these studies predominantly treat digital technologies as external enablers rather than examining how they reshape stakeholders' behavioral responses through cognitive and psychological mechanisms (e.g., perception formation and decision-making processes) (Cranney, de Villiers Scheepers, & Mulcahy, 2025; Tumpa, & Naeni, 2025). This limit understanding of how technology translates into actual integration depth.

Third, research focusing on private vocational colleges emphasizes their dual characteristics of resource constraints and institutional flexibility. Yet, proposed solutions are often generalized, such

as increasing investment or enhancing stakeholder motivation, without identifying operational and mechanism-based pathways for implementation (i.e., Nwala, Kabeyi, & Olanrewaju, 2025). A particularly important gap relates to the Technology Acceptance Model (TAM). While widely applied in voluntary technology adoption contexts, its explanatory power in compulsory or institutionally mandated environments—such as industry–education integration platforms—remains insufficiently tested. Specifically, comparative empirical evidence on the roles of perceived usefulness and perceived ease of use under non-voluntary adoption conditions is still limited (i.e., Davis, 1989; Schlimm, & Breuer, 2026).

Overall, three main gaps are identified:

(a) the absence of a micro-level adaptive mechanism explaining system dynamics; (b) insufficient empirical integration of psychological perception as a mediating construct; and (c) lack of a unified framework integrating new-quality productive forces, digital transformation, and sustainable vocational education development.

Analytical Framework: "Two-Wheel Drive and Four-Dimensional Adaptation (i.e., Lou, Z., Dong, & Cui, 2026)"

To address the identified gaps, this study proposes an integrated theoretical framework grounded in ecosystem theory and the Technology Acceptance Model (TAM) (i.e., Mastour, Yousefi, & Niroumand, 2025). The framework conceptualizes industry–education integration as a dynamic adaptation process consisting of "environmental stimulation–organizational adjustment–psychological perception–behavioral outcome."

Two-Wheel Drive System (Environmental Stimulation) (i.e., Shen, Shang, Guo, & Zhang, 2025).

The external environment is conceptualized as a dual-driver system:

New-quality productive forces (demand-side driver):

This dimension represents the transformation of industrial structure and technological upgrading. It sets new competency requirements for talent cultivation, thereby functioning as the "directional driver" of vocational education reform through high technology, high efficiency, and high-quality development requirements (Woldemichael, 2025).

Digital transformation (supply-side empowerment):

Digital technologies reshape educational delivery systems, acting as the "enabling driver" that supports innovation in teaching models, resource integration, and institutional collaboration mechanisms (Li, & Liu, 2026). This driver accelerates the restructuring of industry–education ecosystems.

Four-Dimensional Adaptation Levers (Organizational Adjustment)

Private vocational colleges respond to external pressures through a structured adaptation mechanism termed the **four-dimensional integration path**, conceptualized as a formative construct (i.e., Banihashemi, Ahmadi, & Ojinezhad, 2025) consisting of:

Goal reshaping:

Aligning institutional training objectives with evolving industrial competency frameworks, thereby enhancing relevance to labor market demands (i.e., Surono, 2025).

Process restructuring:

Innovating curriculum design, teaching methods, and training processes to improve alignment between learning activities and industrial practices (i.e., Alogla, 2025).

Platform reconstruction:

Developing integrated digital–physical training environments that reduce operational barriers and improve accessibility for stakeholders (i.e., Berlato, Binni, Durmus, Gatto, Giusti, Massari, ... & Mirarchi, 2025).

Evaluation reorganization:

Establishing multidimensional assessment systems that ensure continuous feedback and sustainability of integration outcomes.

Together, these dimensions form a structured institutional response mechanism that shapes stakeholder perceptions of usefulness and ease of participation.

Micro Psychological Mechanism (TAM-Based Mediation Logic)

This study integrates the Technology Acceptance Model (TAM) as the micro-level explanatory mechanism. It posits those organizational interventions influence stakeholders' behavioral intentions indirectly through cognitive perceptions (i.e., Kim, Liu, & Ling, 2025).

Specifically, the four-dimensional integration path is expected to enhance:

- **Perceived usefulness (PU):** the extent to which stakeholders believe integration improves performance outcomes
- **Perceived ease of use (PEOU):** the extent to which stakeholders perceive integration systems as effort-efficient

These perceptions subsequently influence the depth of industry–education integration by shaping participation behavior among teachers, administrators, and enterprise partners (Davis, 1989).

Research Hypotheses

(1) Formative construct hypotheses
H1–H4: Each dimension (goal reshaping, process restructuring, platform reconstruction, evaluation reorganization) significantly contributes to the four-dimensional integration path.

(2) Direct effect hypotheses
H5–H7: The four-dimensional integration path significantly influences PU, PEOU, and integration depth.
H8–H9: PU and PEOU significantly influence integration depth.

(3) Mediation hypotheses
H10–H11: PU and PEOU mediate the relationship between the four-dimensional integration path and integration depth.

Research Design and Methodology

Research Sample and Data Collection

This study adopts a multi-stage cluster stratified sampling design to ensure representativeness and methodological rigor (i.e., Zumitzavan, 2026). The sampling frame was constructed using the official list of private higher vocational colleges engaged in industry–education integration projects issued by the Ministry of Education.

In the first stage, 80 private vocational colleges were selected and stratified by geographic region (eastern, central, and western China in a 5:3:2 ratio) (i.e., Li, Dong, Hou, Wang, & Duan, 2025). In the second stage, stratification was conducted based on institutional size (small, medium, and large in a 3:4:3 ratio) and industrial orientation (emerging industries versus traditional industrial upgrading at a 1:1 ratio). Subsequently, 2–3 core majors with established industry–education cooperation of at least two years and collaboration with a minimum of three enterprises were selected to ensure contextual relevance.

In the final stage, respondents were randomly selected from each major group, including college administrators, full-time teachers, enterprise mentors, and enterprise managers.

A total of 250 questionnaires were distributed, and 227 valid responses were retained after data screening. The sample included 40 administrators (17.62%), 147 teachers (64.76%), 33 enterprise mentors (14.54%), 5 enterprise managers (2.20%), and 2 other stakeholders (0.88%). The sample size exceeds the minimum threshold required for PLS-SEM analysis, as verified through G*Power analysis (effect size = 0.15, $\alpha = 0.05$, power = 0.95) and the ten-times rule.

Data quality was ensured by removing responses with completion times below 120 seconds, straight-line response patterns, and missing values exceeding two items in core constructs. Ethical approval was obtained from the institutional ethics committee, and informed consent was secured from all participants. This robust sampling strategy ensures the reliability and generalizability of subsequent structural equation modeling analyses (Hair, Babin, Ringle, Sarstedt, & Becker, 2025).

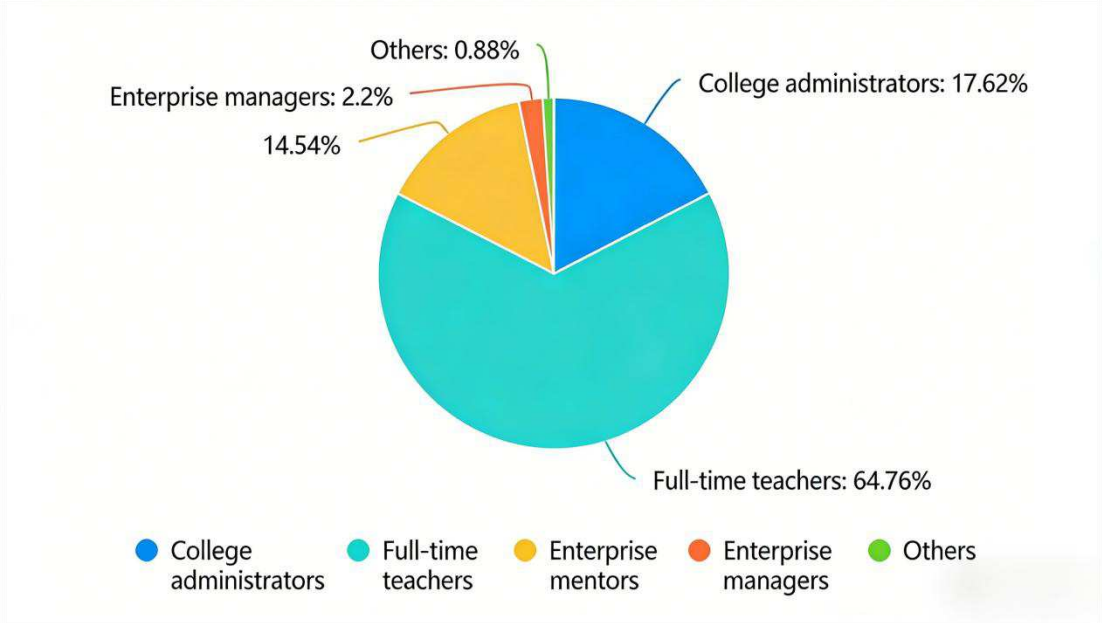


Figure 1. Sample distribution

Regarding professional experience, 64.32% of participants reported having more than five years of relevant work experience, suggesting that the sample possesses substantial practical expertise (see Figure 1). The final valid sample size (N = 227) satisfies the requirements of the PLS-SEM ten-times rule, which recommends that the sample size should be at least ten times greater than the maximum number of indicators associated with the most complex construct in the measurement model (i.e., Darwisman, 2025).

Variables and Measurement Model

The present study defines the independent variable as the *four-dimensional integration path*, which serves as the central theoretical construct of the research model. It is conceptualized as a second-order formative construct composed of four first-order reflective dimensions.

Goal reshaping refers to the extent to which academic programs are aligned with industry demands and emerging competency frameworks, measured using four indicators. Process restructuring captures the degree of innovation in curriculum design and pedagogical approaches, also operationalized through four items. Platform reconstruction assesses the development of integrated virtual–physical learning environments and digital collaboration infrastructures, measured using four indicators. Evaluation reorganization reflects the extent to which institutions adopt diversified, dynamic, and outcome-oriented assessment systems, measured using four items.

The mediating variables in this study represent psychological perceptions derived from the Technology Acceptance Model (TAM).

Perceived usefulness (PU) is defined as participants' subjective evaluation of the extent to which industry–education integration enhances their performance, efficiency, or professional outcomes, measured using four items.

Perceived ease of use (PEOU) refers to the degree to which participants perceive the integration process, platforms, or systems as easy to understand, access, and operate, also measured using four items.

The dependent variable, *depth of industry–education integration*, is conceptualized as a first-order reflective construct. It captures the overall quality and intensity of collaboration between institutions and enterprises across four dimensions: resource investment, scope of cooperation, stability of partnerships, and effectiveness of joint outcomes, measured using four items.

Prior to the main survey, the measurement scale was reviewed by two experts in vocational education and curriculum studies to ensure content validity. A pilot study was then conducted with 35 respondents to test clarity, relevance, and item reliability. Based on expert feedback and pilot results, minor linguistic refinements were made, resulting in a finalized questionnaire comprising 28 measurement items.

Data Analysis Approach

Data analysis was conducted using **Smart PLS 4.0**, employing Partial Least Squares Structural Equation Modeling (PLS-SEM). This technique was selected due to its suitability for complex predictive models involving second-order constructs, multiple mediating effects, and formative–reflective measurement structures. Additionally, PLS-SEM does not impose strict normality assumptions, making it appropriate for behavioral and educational data contexts (Hair et al., 2021).

The analysis followed a two-stage procedure (i.e., Chou, Hsiao, Lu, & Su, 2025):

1. **Measurement model evaluation**, which included assessment of internal consistency reliability (composite reliability), convergent validity (outer loadings and AVE), and discriminant validity using both the Fornell–Larcker criterion and the Heterotrait–Monotrait (HTMT) ratio.
2. **Structural model evaluation and hypothesis testing**, which employed a bootstrapping procedure with 5,000 resamples to determine the significance of path coefficients. Model quality was further evaluated using coefficient of determination (R^2) and predictive relevance (Q^2).

Empirical Model Specification

The **four-dimensional integration path (FDIP)** is operationalized as a higher-order construct formed by four interrelated first-order dimensions: goal reshaping (GR), process restructuring (PR), platform reconstruction (PL), and evaluation reorganization (ER). Collectively, these dimensions

represent the systemic capability of institutions to achieve effective and sustainable industry–education integration.

This hierarchical structure reflects the multidimensional and coordinated nature of vocational education transformation under conditions of digitalization and new-quality productive forces.

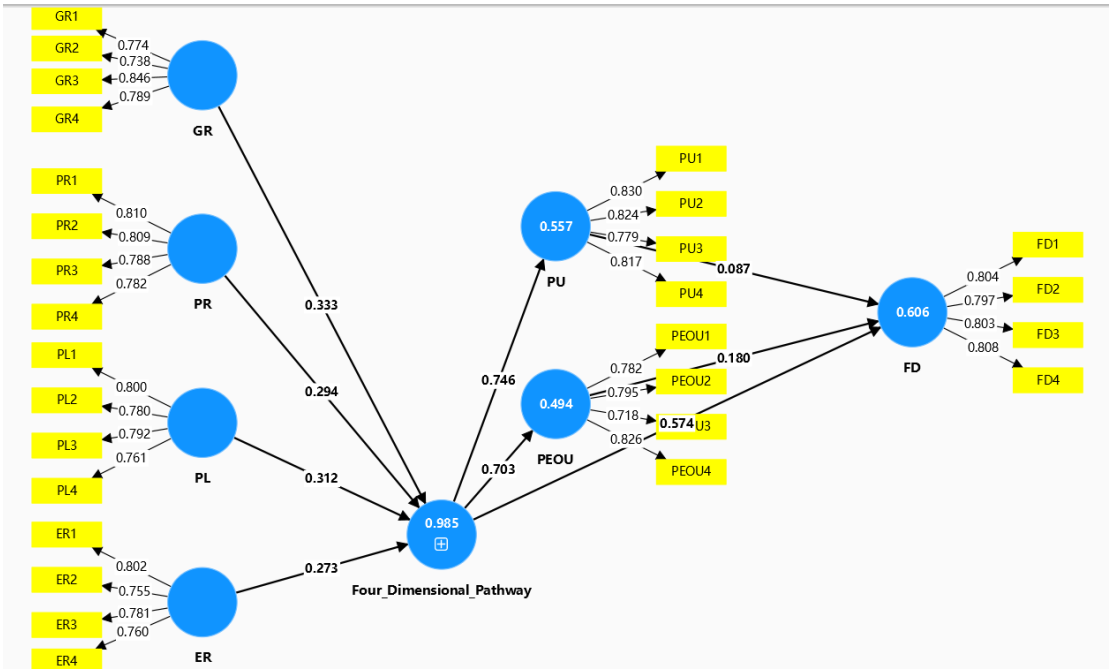


Figure 2. Structural Model and Path Coefficient Results

3.2 Measurement Model Evaluation (Shortened Version)

This study evaluated the measurement model to ensure reliability and validity using PLS-SEM standards.

Reliability and Convergent Validity

All constructs demonstrated strong internal consistency, with Cronbach's alpha (0.778–0.829) and composite reliability (0.777–0.830), exceeding the 0.70 threshold. Indicator loadings were all above 0.70, and AVE values ranged from 0.600 to 0.661, confirming adequate convergent validity.

Table 1

Reliability and Validity Results

Construct	Cronbach's Alpha	Composite Reliability (ρA)	AVE
ER	0.778	0.777	0.600
FD	0.817	0.819	0.645
GR	0.795	0.800	0.620
PEOU	0.788	0.798	0.611
PL	0.790	0.792	0.614
PR	0.809	0.810	0.636
PU	0.829	0.830	0.661

Discriminant Validity

Discriminant validity was confirmed using Fornell–Larcker and HTMT criteria. All constructs met the Fornell–Larcker condition, and HTMT values (0.651–0.807) remained below 0.85 with bootstrap confidence intervals below 1, confirming clear construct distinctiveness.

Table 2

Fornell–Larcker Criterion

	ER	FD	GR	PEOU	PL	PR	PU
ER	0.775						
FD	0.578	0.803					
GR	0.525	0.609	0.788				
PEOU	0.573	0.632	0.528	0.781			
PL	0.610	0.651	0.526	0.576	0.783		
PR	0.626	0.604	0.525	0.574	0.562	0.798	
PU	0.654	0.615	0.605	0.559	0.570	0.613	0.813

Table 3

HTMT Results

Construct Pair	HTMT	95% CI	Result
FD ↔ ER	0.719	[0.612, 0.809]	Yes
GR ↔ ER	0.665	[0.536, 0.780]	Yes
GR ↔ FD	0.747	[0.647, 0.836]	Yes
PEOU ↔ ER	0.726	[0.603, 0.832]	Yes
PEOU ↔ FD	0.770	[0.674, 0.846]	Yes
PL ↔ FD	0.807	[0.696, 0.895]	Yes
PR ↔ FD	0.740	[0.637, 0.824]	Yes
PU ↔ FD	0.742	[0.648, 0.818]	Yes

Formative Construct Evaluation (Summary)

The four-dimensional integration path (GR, PR, PL, ER) showed significant outer weights ($p < 0.001$) and low multicollinearity (VIF = 1.606–2.029), confirming a valid formative construct. All dimensions significantly contribute to the higher-order construct without redundancy.

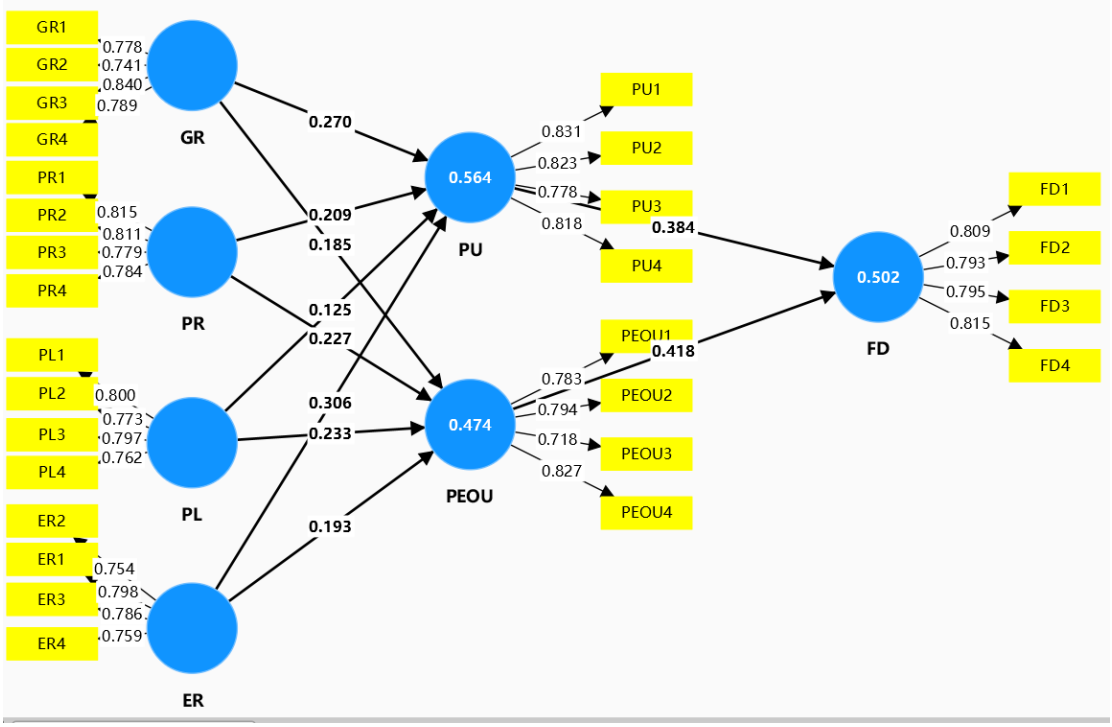


Figure 3: Benchmark Model without Higher Order Concepts

3.4 Structural Model Results (Shortened APA/Scopus Style)

3.4.1 Model Fit and R^2 Comparison

Model fit indicators confirm a stable and robust structural model. The SRMR values for the baseline and target models were 0.054 and 0.059, respectively, both below the recommended threshold of 0.08, indicating good model fit with negligible difference (<0.01).

As shown in Table 4.5, explanatory power remained stable across most constructs, while the depth of industry–education integration (FD) increased notably from 0.502 to 0.606, demonstrating improved predictive capability of the target model. Additionally, path coefficients for perceived usefulness (PU) and perceived ease of use (PEOU) were strong and significant ($\beta = 0.746$, $\beta = 0.703$; $p < 0.001$), supporting the robustness of the proposed framework.

Table 5

R^2 Comparison of Baseline and Target Models

Endogenous Variable	Baseline R^2	Target R^2	Change
PU	0.564	0.557	Slight decrease
PEOU	0.474	0.494	Slight increase
FD	0.502	0.606	Significant increase

Overall, the results confirm strong model stability and improved explanatory power, particularly for FD.

Hypothesis Testing (Direct Effects)

Hypotheses were tested using PLS-SEM with 5,000 bootstrap samples. As shown in Table 4.6, all hypotheses except H9 were supported.

Table 6

Direct Effects and Hypothesis Results

Hypothesis	Path	β	t-value	p-value	Supported
H1	GR → FD Path	0.333	6.261	0.000	Yes
H2	PR → FD Path	0.294	4.816	0.000	Yes
H3	PL → FD Path	0.312	4.991	0.000	Yes
H4	ER → FD Path	0.273	4.543	0.000	Yes

Hypothesis	Path	β	t-value	p-value	Supported
H5	FD → PU	0.746	26.274	0.000	Yes
H6	FD → PEOU	0.703	20.811	0.000	Yes
H7	FD → FD Integration Depth	0.574	7.192	0.000	Yes
H8	PEOU → FD Integration Depth	0.180	2.856	0.004	Yes
H9	PU → FD Integration Depth	0.087	1.315	0.189	No

The findings indicate that the four-dimensional integration path significantly influences perceived usefulness, perceived ease of use, and integration depth. However, only perceived ease of use directly affects integration depth, while perceived usefulness is not significant.

This suggests that in compulsory or institutionally guided environments, ease of use plays a more critical role than perceived usefulness in driving behavioral outcomes.

Explanatory Power (R^2)

The model demonstrates moderate to strong explanatory power (Table 7). The highest explanatory power is observed for FD ($R^2 = 0.606$), indicating strong predictive relevance.

Table 7

R^2 and Adjusted R^2

Construct	R^2	Adjusted R^2
FD	0.606	0.600
PU	0.557	0.555
PEOU	0.494	0.492
Four-Dimensional Path	0.985	0.985

According to Chin (1998), FD demonstrates strong explanatory power, while PU and PEOU reflect moderate levels. The high R^2 for the higher-order construct confirms strong formative validity.

Effect Size and Multicollinearity

Effect size analysis shows that the four-dimensional integration path has strong effects on PU ($f^2 = 1.258$) and PEOU ($f^2 = 0.978$), confirming its central role in the model. However, its direct effects on integration depth via PU and PEOU are weak ($f^2 < 0.05$), indicating a mainly mediating role.

Table 8

f² and VIF

Path	f²	VIF
ER → FDP	2.435	2.029
GR → FDP	4.574	1.606
PR → FDP	3.035	1.895
PL → FDP	3.497	1.848
FDP → FD	0.270	3.084
PU → FD	0.008	2.270
PEOU → FD	0.041	1.988

PU and PEOU show negligible direct effects, indicating mediation roles.

All VIF values (1.000–3.084) are below the threshold of 5.0, confirming no multicollinearity issues and ensuring model stability.

Mediation Analysis

Bootstrap results (5,000 samples) confirm that **perceived ease of use fully mediates** the relationship between the four-dimensional integration path and industry–education integration depth.

Table 9

Mediation Effects

Path	β	t	p	95% CI	Result
FD → PEOU → Integration Depth	0.127	2.825	0.005	[0.051, 0.226]	Yes
PU mediation paths	—	—	>0.05	CI includes 0	No

All mediation paths through PU were non-significant, while all PEOU-based mediation paths were significant.

3.2 Measurement Model Evaluation

The measurement model was assessed for reliability, convergent validity, and discriminant validity using PLS-SEM. Internal consistency was evaluated through Cronbach's alpha and composite reliability, while convergent validity was examined using factor loadings and AVE.

3.2.1 Reliability and Convergent Validity

All constructs demonstrated satisfactory internal consistency, with Cronbach's alpha (0.778–0.829) and composite reliability (0.777–0.830), exceeding the 0.70 threshold. AVE values ranged from 0.600 to 0.661, confirming adequate convergent validity. All item loadings exceeded 0.70.

Predictive Power (Q^2)

Blindfolding analysis confirms predictive relevance.

Table 10

Q^2 Values

Construct	Q^2	Interpretation
FD	0.376	Strong
PU	0.358	Strong
PEOU	0.287	Moderate–strong
FDP	0.405	Strong

All endogenous variables show predictive relevance.

Discussion

This study examined how the four-dimensional integration path influences the depth of industry–education integration in private vocational colleges under the context of new-quality productive forces and digital transformation. Overall, the findings confirm that industry–education integration is driven by a structured organizational mechanism that operates through psychological perception, particularly perceived ease of use as supported by the research (i.e., Cao, Guo, & Li, 2025; Li, & Liu, 2026).

Key findings and theoretical implications

The results validate the four-dimensional integration path (goal reshaping, process restructuring, platform reconstruction, and evaluation reorganization) as a robust second-order formative construct supported by Duan, Guo, Han, Chen, and Chen (2026). All dimensions significantly contribute to the overall integration mechanism, with goal reshaping and platform reconstruction showing relatively stronger effects. This highlights that strategic alignment with industry needs and effective digital infrastructure as found by the researchers (i.e., Malewska, Chwiłkowska-Kubala, & Szumowski, 2025) are the core enablers of integration depth.

Structural results further confirm that the four-dimensional integration path significantly enhances both perceived usefulness and perceived ease of use, as well as directly influencing integration depth supported by Zhong, Moon, and Yu (2025). This indicates that organizational reform shapes both system-level outcomes and stakeholder perceptions simultaneously.

Extension of TAM in vocational education context

A key contribution is the extension of the Technology Acceptance Model in a mandatory-use context. Unlike classical TAM findings, perceived usefulness does not significantly affect integration depth, while perceived ease of use shows a significant positive effect as found by Hussain, Zhiqiang, Li, Jameel, Kanwel, Ahmad and Ge (2025). This suggests that in institutionally driven environments, behavioral outcomes depend more on usability than on perceived functional value.

These findings challenge traditional TAM assumptions and confirm that in vocational education systems, ease of use becomes the dominant psychological driver when participation is structurally required rather than voluntary (i.e., Hou, 2025; Rawashdeh, 2025).

Mediating mechanism

Mediation analysis shows that perceived ease of use fully transmits the effect of the four-dimensional integration path on integration depth, whereas perceived usefulness has no significant mediating role (i.e., Zhong, Moon, & Yu, 2025). This indicates that institutional reforms improve integration primarily by reducing operational complexity rather than by increasing perceived value as supported by other studies (i.e., Zhong, & Um, 2025).

Thus, psychological acceptance in industry–education integration is shaped more by system accessibility and usability than by cognitive evaluation of benefits (Marian, Apostolache & Ceobanu, 2025).

Conclusion

The model demonstrates strong reliability, validity, and predictive capability. The four-dimensional integration path is a robust second-order formative construct driving industry–education integration. Structural results confirm that perceived ease of use, rather than perceived usefulness, plays the dominant mediating role, indicating that usability is a critical determinant in mandatory educational integration contexts. The findings extend TAM theory and provide a validated empirical framework for understanding vocational education transformation under new-quality productive forces.

Practical implications

The results suggest that improving industry–education integration requires prioritizing user-friendly systems, simplified processes, and accessible digital platforms. While strategic alignment and evaluation reforms are important, their effectiveness largely depends on how easily stakeholders can engage with integration mechanisms.

Declarations

Ethics approval: This study was approved by the Academic Ethics Committee of INTI international university and Xingtai Vocational College of Applied Technology in accordance with the

Declaration of Helsinki and relevant national ethical guidelines for educational research involving human participants.

Consent to participate: All respondents participated in the survey with informed consent, and all experiments were performed in accordance with relevant guidelines and regulations.

Consent to publish: Not applicable (the study does not involve any identifiable images or personal data).

Data availability: The data described in this study are openly available in Figshare and Dryad at the DOI locations referenced in the text.

References

Alogla, A. A. (2025). Engineering curriculum redesign for sustainable careers: a process mapping approach in higher education. *Journal of Umm Al-Qura University for Engineering and Architecture*, 1-14.

Badda, A. (2025). Technology Acceptance Model (TAM): Literature Review. *International Journal of Accounting Finance Auditing Management and Economics*, *6*(11), 459-492.

Banihashemi, S., Ahmadi, E., & Ojinezhad, A. (2025). Evaluation of the conceptual model of organizational metamorphosis with an environmental adaptation approach to education. *Journal of Education Experiences*, *8*(1), 119-136.

Berlato, M., Binni, L., Durmus, D., Gatto, C., Giusti, L., Massari, A., ... & Mirarchi, C. (2025). Digital platforms for the built environment: A systematic review across sectors and scales. *Buildings*, *15*(14), 2432.

Cao, A., Guo, L., & Li, H. (2025). Understanding farmer cooperatives' intention to adopt digital technology: mediating effect of perceived ease of use and moderating effects of internet usage and training. *International Journal of Agricultural Sustainability*, *23*(1), 2464523.

Chou, Y. H., Hsiao, K. L., Lu, Y. T., & Su, Y. S. (2025). Exploring the factors affecting the intention to use AI systems in the health-care field with social cognitive theory: a two-stage SEM-ANN approach. *Chinese Management Studies*.

Cranney, S., de Villiers Scheepers, M., & Mulcahy, R. (2025). Human and technological actors shaping digital transformation capability: an integrative review. *Management Decision*, *63*(13), 210-243.

Darwisman, S. (2025). From model to interpretation: A comprehensive and critical guide to PLS-SEM implementation in scientific research. *Journal Internasional of Management and Business*, *1*(1), 1-28.

Davis, F.D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13 (3), w319-340.

Daumiller, M., & Meyer, J. (2025). Advancing feedback research in educational psychology: Insights into feedback processes and determinants of effectiveness. *Contemporary Educational Psychology*, 102390.

Duan, H., Guo, Q., Han, J., Chen, N., & Chen, H. (2026). Development and Validation of the Common Prosperity Aspiration Scale: A Mixed-Methods Study in China. *Behavioral Sciences*, *16*(2), 203.

Düzgünçınar, T. (2025). Bridging the gap between industry needs and vocational training curricula. *Journal of Information Systems Engineering and Management*, *10*, 693-707.

Ferreira, J. A., Tukaiev, S., & Lopes, R. P. (2026). Enhancing policymaking in education: Towards collaborative and evidence-informed approaches. *Policy Futures in Education*, *24*(2), 301-312.

Guo, L., Wang, L., Zhou, F., & Luo, M. (2026). The High-Quality Employment Effects of Digital-Intelligent Economy: Evidence from the China Labor-Force Dynamics Survey. *Social Indicators Research*, *181*(3), 67.

Hair, J. F., Babin, B. J., Ringle, C. M., Sarstedt, M., & Becker, J. M. (2025). Covariance-based structural equation modeling (CB-SEM): a SmartPLS 4 software tutorial: JF Hair et al.

Hou, S. (2025). Exploring learner acceptance and experience in MOOCs among higher vocational students from a TAM perspective: a case study of college English course. *Frontiers in Psychology*, *16*, 1643166.

Huang, F. (2025). Exploring a new model of undergraduate vocational education. *Vocation, Technology & Education*, *2*(1).

Hussain, A., Zhiqiang, M., Li, M., Jameel, A., Kanwel, S., Ahmad, S., & Ge, B. (2025). The mediating effects of perceived usefulness and perceived ease of use on nurses' intentions to adopt advanced technology. *BMC nursing*, *24*(1), 33.

Jacobs, L. L., & Goedhals-Gerber, L. L. (2026). Bridging the digital divide: Evaluating maritime education curricula against Fourth Industrial Revolution competency demands in South Africa. *Journal of Transport and Supply Chain Management*, *20*, 1202.

Kim, B., Liu, A., & Ling, E. C. (2025). Effects of disability employment on guest perceptions and behavioral intentions in the hotel sector. *International journal of hospitality management*, *124*, 103993.

Li, D., Dong, W., Hou, Z., Wang, H., & Duan, Y. (2025). Characteristic Analysis of the Evolution of the Temporal and Spatial Patterns of China's Iron and Steel Industry from 2005 to 2023. *Sustainability*, *17*(19), 8623.

Li, J., Jin, M., & Chen, X. (2025). Understanding continued use of smart learning platforms: psychological wellbeing in an extended TAM-ISCM model. *Frontiers in psychology*, *16*, 1521174.

Li, X., & Liu, X. (2026). Spatial interplay between digital–real integration and new quality productive forces: Evidence from China. *Systems*, *14*(3), 298.

Lou, Z., Dong, T., & Cui, T. (2026, January). Unmanned freight vehicle design under complex adaptive system. In *International Conference on Mechanical, Engineering, and Interaction Design (ICMEID 2025)* (Vol. 14018, pp. 2324-2335). SPIE.

Malewska, K., Chwiłkowska-Kubala, A., & Szumowski, W. (2025). Digital technology infrastructure management and business strategic alignment as enablers of digital capabilities in energy SMEs. *Economics and Environment*, *94*(3), 1026-1026.

Marian, A. L., Apostolache, R., & Ceobanu, C. M. (2025). Toward sustainable technology use in education: Psychological pathways and professional status effects in the TAM framework. *Sustainability*, *17*(15), 7025.

Mastour, H., Yousefi, R., & Niroumand, S. (2025). Exploring the acceptance of e-learning in health professions education in Iran based on the technology acceptance model (TAM). *Scientific Reports*, *15*(1), 8178.

Nwala, K. C., Kabeyi, M. J. B., & Olanrewaju, O. A. (2025). A visual and strategic framework for integrated renewable energy systems: Bridging technological, economic, environmental, social, and regulatory dimensions. *Energies*, *18*(20), 5468.

Rawashdeh, A. (2025). Catalysts of transformation: Unravelling the nexus between regulatory changes, perceived efficiency gains, and business performance in blockchain implementation. *International Journal of Productivity and Performance Management*, *74*(10), 3577-3600.

Schlimm, J., & Breuer, C. (2026). Understanding the factors that drive AI adoption among sports consumers–an extended TAM perspective. *International Journal of Sports Marketing and Sponsorship*, *27*(1), 174-198.

Shen, N., Shang, X., Guo, W., & Zhang, G. (2025). Evolution of regional collaborative innovation network by the 'two-wheel drive'of external proximity and endogenous gravity. *Technology Analysis & Strategic Management*, *37*(12), 3251-3270.

Steinhauser, S. (2025). Understanding decision support adoption by European physicians: shifts in micro-and macro-level influences over time. *Information Technology and Management*, 1-35.

Surono, S. (2025). Unit of Competency for Development of Occupational Standards to Align Workforce Competence with Labor Market Demands and Educational Outcomes. *Edunity Kajian Ilmu Sosial dan Pendidikan*, *4*(5), 178-190.

Ta, D. P., & Pham, N. S. (2026). Managing Assessment in Vocational Education through Digital Transformation: Evidence from Secondary Vocational Schools in Hanoi, Vietnam. *E-Learning Innovations Journal*, *4*(1), 49-72.

Tumpa, R. J., & Naeni, L. (2025). Improving decision-making and stakeholder engagement at project governance using digital technology for sustainable infrastructure projects. *Smart and Sustainable Built Environment*, *14*(4), 1292-1329.

Uzule, K. (2026). A conceptual model for implementing inclusive higher education at the meso-level: integrating sharing economy and integrated reporting principles. *European Journal of Special Needs Education*, 1-36.

Weishaupt, J., Kuhn, A., Baatz, C., & Vafeidis, A. T. (2026). Stakeholder preferences and perceived effectiveness of coastal adaptation measures in Seychelles. *npj Climate Action*, *5*(1), 16.

Woldemichael, S. (2025). Determinants of Integration: Migration Difficulty, Mental Health, and Social Connections among Eritrean Immigrants.

Zhong, D., & Um, K. H. (2025). How customer integration drives green innovation: exploring the influence of regulatory pressures and market changes. *Journal of Manufacturing Technology Management*, *36*(3), 731-754.

Zhong, Y., Moon, H. C., & Yu, M. (2025). Proposing a four-dimension model to study the drivers of Industry 4.0 technology adoption and service innovation from a moderated mediation perspective. *Technology Analysis & Strategic Management*, 1-17.

Zumitzavan, V. (2026). Sample Selection Methods. In *Social Science Methodologies for Management Research: From Philosophy to Practice in the AI Era* (pp. 79-95). Singapore: Springer Nature Singapore.