Problem-Based and Project-Based Learning Strategies for Technology-Enhanced Entrepreneurship Education: Recommendations from a Vocational College Study

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ABSTRACT

Vocational colleges are under growing pressure to produce graduates who can convert entrepreneurial knowledge into practical, technology-supported action. Although prior research confirms that curriculum design, experiential practice, and industry-aligned integration improve entrepreneurship education performance, far less guidance exists on how vocational institutions should operationalise these findings pedagogically. This paper addresses that gap by translating evidence from a survey of 503 students enrolled in entrepreneurship courses at vocational colleges in Zhejiang Province, China, into actionable problem-based learning (PBL) and project-based learning (PjBL) strategies for technology-enhanced entrepreneurship education. The underlying study, grounded in technology adoption and experiential learning theories, employed structural equation modelling and found that entrepreneurship curriculum, entrepreneurship practice, and the integration of specialization and entrepreneurship significantly predicted students' digital technology engagement, which in turn significantly predicted entrepreneurship education performance and partially mediated the effects of the three educational inputs. Building on these results, the paper proposes a five-stage technology-enhanced PBL–PjBL implementation cycle comprising problem and project framing, digital resource orchestration, guided inquiry and prototyping, authentic assessment, and reflection and transfer. Recommendations are offered for instructors, curriculum designers, and institutional leaders, including the co-design of authentic problems with industry partners, the embedding of simulation and business-modelling platforms within project tasks, competency-based digital assessment, and structured reflection that links entrepreneurial learning to career pathways. The paper contributes a practice-oriented framework that connects empirical evidence on technology-mediated entrepreneurship education with concrete pedagogical design decisions in vocational settings, supporting the development of digitally supported, practice-oriented, and career-aligned entrepreneurship programmes. Because the underlying evidence was generated in a single provincial context and the proposed cycle has not yet been experimentally trialled, the paper additionally specifies the contextual boundary conditions that govern its transfer to other vocational systems and sets out a staged agenda of design-based, quasi-experimental, multi-site, and longitudinal studies through which the framework can be tested.

Keywords: problem-based learning, project-based learning, entrepreneurship education, digital technology, vocational colleges

INTRODUCTION

Entrepreneurship education has become a strategic priority for vocational education systems worldwide as digital transformation reshapes labour markets and the competencies graduates require (Sitaridis & Kitsios, 2024; Ratten & Usmanij, 2021). In China, national policy has explicitly positioned vocational education as an engine of innovation-driven development, encouraging colleges to integrate entrepreneurship education with digital infrastructure, virtual simulation platforms, and industry partnerships (Ministry of Education of the People's Republic of China, 2022; Liao & Yturralde, 2024). Yet policy ambition alone does not guarantee pedagogical quality. Many vocational entrepreneurship courses remain dominated by lecture-based knowledge transmission, with limited opportunities for students to solve authentic problems, build ventures, or use professional digital tools in the process (Chen et al., 2021; Zhao & Watterston, 2021).

The urgency of this pedagogical question is amplified by the structural transformation of the economy that vocational graduates are entering. The digital economy now accounts for a substantial and growing share of national output in China, and employers increasingly demand hybrid skill profiles that combine occupational expertise with digital fluency and entrepreneurial capability (Ministry of Education of the People's Republic of China, 2022; Zhang & Huang, 2023). Vocational colleges enrol millions of students whose employment prospects depend directly on how well their programmes anticipate these demands. National initiatives have accordingly promoted smart education platforms, virtual simulation training bases, and standards for teacher digital literacy, creating an infrastructure layer on which pedagogical innovation can be built (Zhang & Huang, 2023; Alenezi et al., 2023). What remains underdeveloped is the instructional layer: a systematic account of how teachers should structure entrepreneurship learning so that this infrastructure is converted into measurable student outcomes. Problem-based and project-based learning offer precisely such an account, because they specify how problems are framed, how resources are mobilised, how inquiry is guided, how performance is assessed, and how learning is transferred.

A substantial body of evidence indicates that experiential, learner-centred pedagogies are more effective in developing entrepreneurial competence than traditional instruction (Nabi et al., 2017; Lackéus, 2020; Hägg & Kurczewska, 2021). Two approaches stand out. Problem-based learning (PBL) organises learning around ill-structured, authentic problems that students investigate collaboratively, developing analytical reasoning and self-directed learning (Hmelo-Silver, 2004; Raimundo & Rosário, 2024).

Project-based learning (PjBL) extends this logic by requiring learners to produce concrete artefacts such as business plans, prototypes, or operating micro-ventures over an extended period (Guo et al., 2020; Almulla, 2020; Santoso et al., 2023). Both approaches align naturally with entrepreneurship, a discipline that is itself defined by problem identification, opportunity development, and value creation under uncertainty (Kickul et al., 2018; Gomez, 2024).

At the same time, entrepreneurship education has become deeply intertwined with digital technology. Learning increasingly occurs through simulation platforms, online collaboration environments, business-modelling software, and data-analytic tools (Secundo et al., 2021; Dabbous & Boustani, 2023). Digital technology is no longer a peripheral delivery channel; it constitutes a behavioural pathway through which educational inputs are converted into performance outcomes (Qin & Kamrozzaman, 2026).

Research in Malaysian higher education similarly demonstrates that thoughtfully designed technology-mediated learning can strengthen learner autonomy, engagement, and sustainable educational outcomes (Kamrozzaman et al., 2020; Kamrozzaman, 2025). The question facing vocational colleges is therefore not whether to combine experiential pedagogy with digital technology, but how to do so systematically.

This paper responds to that question. It draws on the findings of a quantitative study of 503 vocational college students in Zhejiang Province, China, which examined how entrepreneurship curriculum (EC), entrepreneurship practice (EP), and the integration of entrepreneurship and professional education (IEEPE) influence entrepreneurship education performance (EEP) through students' use of digital technology (Qin & Kamrozzaman, 2026).

Rather than re-testing the structural model, the present paper has a translational purpose: it converts the empirical evidence into design principles and implementation strategies grounded in PBL and PjBL. Specifically, the paper (1) synthesises the theoretical and empirical rationale for technology-enhanced PBL and PjBL in vocational entrepreneurship education; (2) summarises the evidence base from the Zhejiang study; (3) proposes a five-stage implementation framework; (4) offers recommendations for instructors, curriculum designers, and institutional leaders; and (5) specifies the contextual boundary conditions that govern transfer of the framework to other vocational systems, together with a staged agenda for its empirical and longitudinal validation.

LITERATURE REVIEW

Entrepreneurship Education in Vocational Contexts

Entrepreneurship education aims to develop the knowledge, skills, and attitudes required to turn ideas into action (Bacigalupo et al., 2016; Duong, 2022). Meta-analytic and systematic evidence confirms positive but heterogeneous effects on entrepreneurial intention, competence, and employability, with pedagogy identified as a decisive moderator of impact (Nabi et al., 2017; Decker-Lange et al., 2024). Vocational education offers a distinctive context for entrepreneurship education because it is inherently practice-oriented, learner-centred, and closely connected to industry (Bauer et al., 2025; Green & du Plessis, 2023). Vocational students typically bring occupational identities and workplace exposure that make career-relevant entrepreneurial learning both feasible and motivating. However, studies also show that vocational entrepreneurship provision is frequently fragmented, with curriculum, practical activities, and specialization taught as separate components rather than as an integrated system (Qin & Kamrozzaman, 2026; Liao & Yturralde, 2024).

Problem-Based and Project-Based Learning in Entrepreneurship Education

PBL originated in medical education and is characterised by learning triggered by an authentic, ill-structured problem, collaborative small-group inquiry, tutor facilitation rather than lecturing, and self-directed knowledge construction (Hmelo-Silver, 2004). A recent bibliometric systematic review of 142 studies concludes that PBL is increasingly adopted across entrepreneurial processes in both higher education and industry, supporting opportunity recognition, decision-making under uncertainty, and entrepreneurial mindset development (Raimundo & Rosário, 2024). In vocational teacher education, scaffolded cooperative PBL has been shown to improve entrepreneurial attitudes and to shape how future instructors intend to teach entrepreneurship themselves (Widiastuti et al., 2025).

PjBL shares PBL's constructivist foundations but places greater emphasis on the production of artefacts and sustained engagement over time (Guo et al., 2020). In entrepreneurship education, PjBL commonly takes the form of venture creation projects, business-model development, and industry-commissioned briefs (Santoso et al., 2023; Pei et al., 2023). Evidence indicates that PjBL enhances learner autonomy, teamwork, and knowledge application in technical and vocational settings (Green & du Plessis, 2023; Almulla, 2020), and that project- and challenge-based formats strengthen the entrepreneurial mindset of university students (Colombelli et al., 2022). Comparative research further suggests that the intensity of experiential engagement matters: fully venture-based approaches produce stronger entrepreneurial competence development than lighter, discussion-based formats (Lackéus, 2020; Bell & Bell, 2020).

Digital Technology as A Learning Mechanism

Technology adoption research, anchored in the Technology Acceptance Model and the Unified Theory of Acceptance and Use of Technology, holds that perceived usefulness, ease of use, facilitating conditions, and motivation drive individuals' actual technology use (Davis, 1989; Venkatesh et al., 2003). In education, these behavioural mechanisms determine whether digital tools are genuinely engaged with or remain unused infrastructure (Chen et al., 2021; García-Morales et al., 2021). Systematic reviews of online and blended entrepreneurship education document a rapidly expanding toolkit, including simulations, serious games, learning management systems, video pitching, and collaborative cloud platforms, while noting that the pedagogical integration of these tools, not their mere availability, explains learning gains (Chen et al., 2021; Fox et al., 2018; Sitaridis & Kitsios, 2024).

The two theoretical traditions underpinning this paper are complementary and map directly onto instructional design decisions. From the technology adoption tradition, performance expectancy corresponds to students' belief that digital tools will improve their entrepreneurial work, which instructors can strengthen by demonstrating professional use cases; effort expectancy corresponds to perceived ease of use, addressed through onboarding and scaffolded tool introduction; facilitating conditions correspond to institutional support such as access, training, and technical assistance; and social influence corresponds to peer and mentor norms established in team-based projects (Davis, 1989; Venkatesh et al., 2003). From the experiential learning tradition, Kolb's (1984) four-stage cycle specifies that effective learning requires concrete experience, reflective observation, abstract conceptualisation, and active experimentation in sequence. Problem-based and project-based learning provide the concrete experience and active experimentation stages, while structured debriefing and portfolio work provide reflective observation and conceptualisation (Bell & Bell, 2020; Hernández-Ramos et al., 2021). When digital platforms host each of these stages, technology engagement becomes the connective tissue of the entire learning cycle rather than an isolated activity.

Recent empirical work positions digital technology use as a mediating behaviour rather than a background condition. The Zhejiang study found that digital technology use significantly mediated the relationships between curriculum, practice, integration, and performance, and that the integration of specialization and entrepreneurship moderated the practice–technology relationship (Qin & Kamrozzaman, 2026). This aligns with broader findings that digital transformation reconfigures, rather than merely supplements, entrepreneurial learning processes (Secundo et al., 2021; Sitaridis & Kitsios, 2024), and with evidence that learners' challenges in adopting emerging technologies such as artificial intelligence must be deliberately addressed in instructional design (Jie & Kamrozzaman, 2024). Experiential learning theory offers the complementary pedagogical logic: knowledge is created through the transformation of experience across cycles of concrete experience, reflective observation, abstract conceptualisation, and active experimentation (Kolb, 1984). Technology-enhanced PBL and PjBL operationalise this cycle by supplying authentic experiences, digital spaces for reflection and collaboration, and platforms for experimentation (Hernández-Ramos et al., 2021; Aydın & Mutlu, 2023).

Digital Transformation of Vocational Education

Understanding the context of vocational education digitalisation is essential for situating the proposed framework. Over the past five years, vocational education systems have undergone an accelerated digital transformation driven by policy mandates, pandemic-era disruption, and labour market change (García-Morales et al., 2021; Zhao & Watterston, 2021). In China, the revised Vocational Education Law elevated vocational education to a status equal to general education and explicitly encouraged the integration of digital technology into teaching, management, and industry cooperation (Ministry of Education of the People's Republic of China, 2022). Case evidence from Chinese vocational colleges documents large repositories of online open courses, virtual simulation materials, and integrated smart-campus systems, indicating that the infrastructure for technology-enhanced pedagogy is increasingly in place (Zhang & Huang, 2023).

However, infrastructure availability does not automatically translate into pedagogical use. Studies of digital education integration consistently report a gap between institutional provision and classroom practice, attributable to limited teacher readiness, assessment systems that reward reproduction rather than application, and the absence of instructional models that specify how tools should be embedded in learning tasks (Alenezi et al., 2023; Chen et al., 2021). In entrepreneurship education specifically, digitalisation has often taken the form of content delivery through learning management systems rather than authentic entrepreneurial activity mediated by professional tools (Sitaridis & Kitsios, 2024; Liao & Yturralde, 2024). This distinction matters because the behavioural evidence reviewed above indicates that performance gains flow from active, purposeful technology engagement, not from passive exposure to digitised content. The framework proposed in this paper is designed to close this provision-to-practice gap.

The Research Gap

Three gaps motivate this paper. First, most PBL and PjBL research in entrepreneurship education concerns universities; vocational colleges, despite their scale in systems such as China's, remain under-represented (Widiastuti et al., 2025; Bauer et al., 2025). Second, studies that confirm the mediating role of technology rarely translate their structural findings into concrete pedagogical designs (Qin & Kamrozzaman, 2026; Iwu et al., 2024). Third, implementation guidance that simultaneously addresses curriculum design, practice activities, industry integration, and technology orchestration is scarce, leaving practitioners to assemble fragmented advice (Boelt et al., 2022; Alenezi et al., 2023). This paper addresses these gaps by proposing an integrated, evidence-based implementation framework.

METHODOLOGY

Research Design

This paper adopts a translational design-recommendation approach: it derives pedagogical strategies from the empirical findings of a completed quantitative study, interpreted through the lens of the PBL and PjBL literature. This design is appropriate because the objective is not to test new hypotheses but to convert validated structural evidence into implementable pedagogy for vocational colleges. The underlying study employed a quantitative, cross-sectional survey design grounded in technology adoption theory and experiential learning theory; full psychometric and structural details are reported in Qin and Kamrozzaman (2026). The epistemic status of the resulting framework should be stated plainly. Its structural premises have been tested empirically, but the five-stage cycle assembled from them has not itself been subjected to experimental, design-based, or longitudinal trial. It is therefore advanced as a testable blueprint rather than a validated intervention, and its component propositions are made explicit throughout precisely so that subsequent studies can confirm, qualify, or refute them.

Participants and Sampling

The source study surveyed 503 students enrolled in entrepreneurship education courses at vocational colleges in Zhejiang Province, China, selected through stratified random sampling across institutions and study programmes to ensure adequate representation. Respondents came from diverse disciplinary backgrounds, including business management, engineering, and applied sciences, and all had prior exposure to curriculum-based entrepreneurship education and practice-oriented learning activities involving digital technologies. Participation was voluntary, institutional approval was obtained, and confidentiality of respondents was assured.

Instrument and Data Collection

Five constructs were measured on five-point Likert scales adapted from established literature: entrepreneurship education curriculum (EC), entrepreneurship practice (EP), integration of specialization and entrepreneurship (IEEPE), digital technology use (UT), and entrepreneurship education performance (EEP). A pilot study was conducted before the main data collection to confirm the clarity, reliability, and validity of the instrument. Questionnaires were distributed both physically and electronically. Confirmatory factor analysis demonstrated satisfactory measurement quality, with composite reliability values between 0.88 and 0.92 and average variance extracted exceeding 0.60 for all constructs, supporting convergent and discriminant validity.

Each construct was operationalised through multiple observed indicators. The curriculum construct (EC) captured the integration of digital content into course materials, the use of technology-driven pedagogical approaches, competency-based assessment practices, and the adequacy of learning resource support. The practice construct (EP) measured the frequency of digital tool experience, the quality of collaborative learning environments, the situational authenticity of practice tasks, and the availability of mentor and task-based support. The integration construct (IEEPE) assessed interdisciplinary collaboration, the infusion of entrepreneurial elements into subject-specific courses, linkage to real industry problems, and the transferability of entrepreneurial competencies to professional practice. The technology use construct (UT) covered frequency and ease of use, technology self-efficacy, institutional supporting conditions, and intrinsic motivation for technology-mediated learning. The performance construct (EEP) encompassed entrepreneurial competence, application ability, behaviour-competence matching, and perceived educational effectiveness. All items were reviewed by subject-matter experts for content validity prior to administration.

Data Analysis

Structural equation modelling with bias-corrected bootstrapped mediation analysis tested the hypothesised relationships, and hierarchical regression examined the moderating role of IEEPE. Model fit indices met conventional thresholds (χ^2/df = 2.28; RMSEA = 0.059; CFI = 0.94; TLI = 0.93). For the present paper, the validated structural results were then mapped onto PBL and PjBL design principles drawn from the literature to construct the implementation framework.

Structural equation modelling was appropriate for this evidence base because it estimates a system of relationships among latent constructs simultaneously, separates measurement error from structural relationships, and permits the direct testing of mediation and moderation hypotheses (Qin & Kamrozzaman, 2026). Procedural remedies for common method concerns included assurance of anonymity, separation of predictor and outcome items within the questionnaire, and the use of previously validated item wording. The translational step of the present paper followed a three-part procedure: first, each significant structural path was restated as a design requirement; second, the PBL and PjBL literature was searched for instructional mechanisms known to satisfy each requirement; third, the mechanisms were sequenced into an implementation cycle consistent with experiential learning theory and validated against the practical constraints reported in the vocational education literature.

RESULTS

Four findings anchor the pedagogical translation, as summarised in Table 1. First, entrepreneurship curriculum and entrepreneurship practice exerted significant positive direct effects on entrepreneurship education performance ($\beta = 0.22$ and $\beta = 0.31$ respectively), confirming the foundational value of structured content and experiential activity. Second, digital technology use showed the strongest direct effect on performance ($\beta = 0.46$) and significantly mediated the effects of curriculum, practice, and integration on performance. Third, the integration of specialization and entrepreneurship did not directly improve performance but significantly moderated the relationship between practice and technology use ($\beta = 0.15$), meaning that practice-based learning stimulates deeper technology engagement when it is embedded in discipline- and career-relevant contexts. Fourth, all three educational inputs significantly predicted technology use, indicating that pedagogy shapes the very behaviour through which performance is generated (Qin & Kamrozzaman, 2026).

The direct effects deserve careful interpretation because they define what curriculum and practice must accomplish independently of technology. The significant curriculum effect indicates that structured knowledge, clear pedagogical guidance, and competency-based assessment remain necessary foundations: students cannot inquire productively into problems for which they lack conceptual anchors. The stronger practice effect ($\beta = 0.31$ versus $\beta = 0.22$) supports the long-standing claim of experiential entrepreneurship scholarship that doing outperforms hearing (Nabi et al., 2017; Lackéus, 2020). The non-significant direct effect of integration is the most instructive result for programme designers: adding integration modules or interdisciplinary labels to a programme does not, by itself, raise performance. Integration creates value only through the conditions it establishes for practice and technology engagement, which explains why isolated integration initiatives frequently disappoint (Huang et al., 2024; Liu et al., 2024).

The mediation and moderation results define the mechanism the pedagogy must activate. The dominant effect of digital technology use ($\beta = 0.46$) and its significant mediation of all three input-to-performance relationships indicate that educational inputs are converted into outcomes largely through what students actually do with technology: searching, modelling, simulating, collaborating, and producing. Partial rather than full mediation shows that curriculum and practice retain some direct value, but the largest share of their influence travels through the behavioural channel. The significant interaction between practice and integration ($\beta = 0.15$) further specifies the boundary condition: when practice tasks are deeply embedded in students' disciplinary fields and connected to real industry problems, each hour of practice generates more technology engagement, and therefore more performance, than the same hour spent on generic exercises. These are precisely the conditions that well-designed PBL and PjBL create by default.

Table 1. Summary of structural model results informing the recommendations (Qin & Kamrozzaman, 2026)

Hypothesised path	β	Result
Entrepreneurship curriculum → Performance	0.22	Significant
Entrepreneurship practice → Performance	0.31	Significant
Integration (IEEPE) → Performance	0.05	Not significant
Digital technology use → Performance	0.46	Significant
Curriculum, practice, IEEPE → Technology use	n/a	All significant
Practice × IEEPE → Technology use (moderation)	0.15	Significant
Indirect effects via technology use (mediation)	n/a	Significant (partial)

Figure 1 presents the evidence-based conceptual model that underpins the recommendations developed in the remainder of this paper. Solid arrows denote the mediated pathway through digital technology engagement; dashed arrows denote the direct pathways consistent with partial mediation.

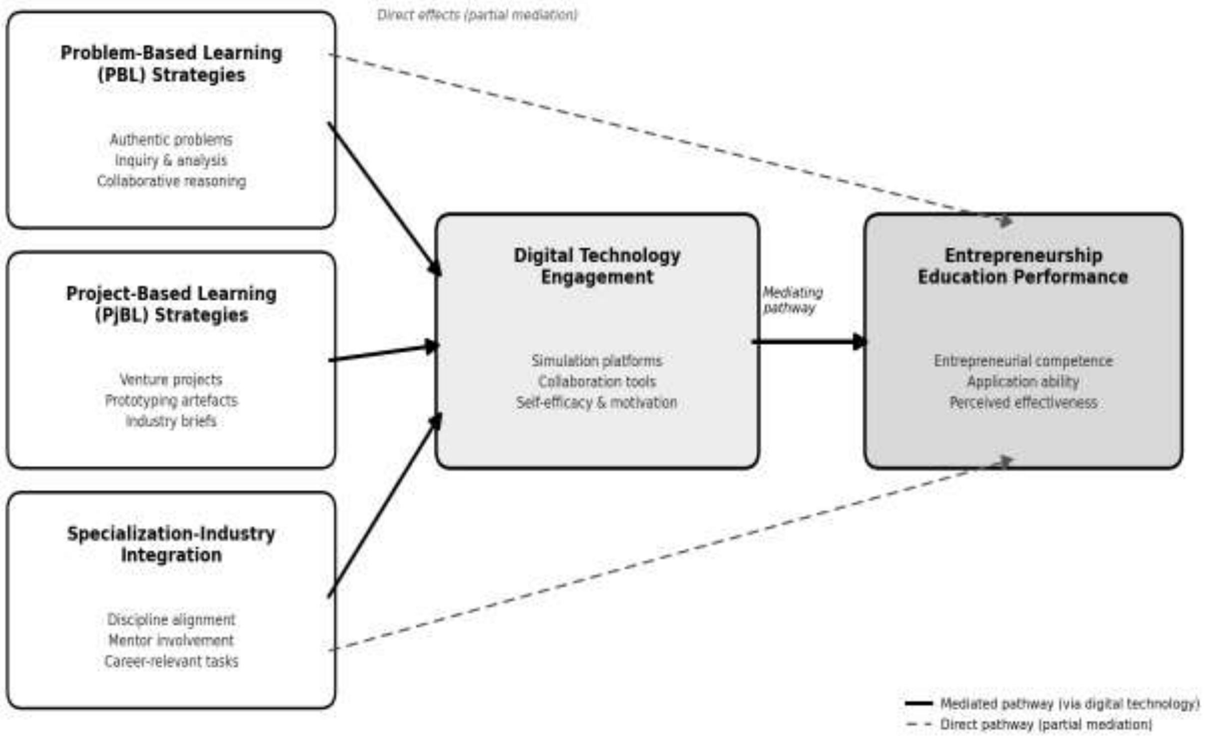

Figure 1. Evidence-based conceptual model linking PBL and PjBL strategies to entrepreneurship education performance through digital technology engagement

A Technology-Enhanced PBL–PJBL Implementation Framework

The empirical findings imply a clear design logic: vocational entrepreneurship education improves when curriculum, practice, and integration are engineered to maximise meaningful digital technology engagement. PBL and PjBL provide the pedagogical architecture best suited to this logic, because both approaches require students to use tools purposefully in pursuit of authentic goals rather than to consume content passively (Hmelo-Silver, 2004; Guo et al., 2020; Raimundo & Rosário, 2024). Drawing on the evidence and on experiential learning theory (Kolb, 1984), this paper proposes a five-stage implementation cycle, illustrated in Figure 2.

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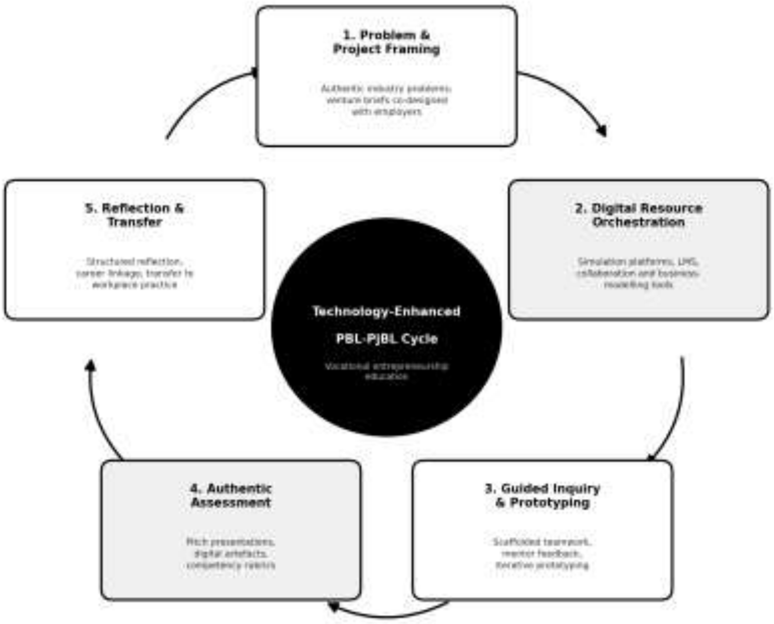

Figure 2. The five-stage technology-enhanced PBL–PjBL implementation cycle for vocational entrepreneurship education

Problem and Project Framing

Each learning unit begins with an ill-structured problem or venture brief co-designed with industry partners and mapped to students' specializations. Because the moderation finding shows that practice stimulates technology engagement most strongly when it is career-relevant, problems should originate from the occupational fields students are training for. For example, suitable briefs include digitalising a logistics process for supply-chain students or designing an e-commerce launch for marketing students (Qin & Kamrozzaman, 2026; Liao & Yturralde, 2024). Well-framed problems are authentic, open-ended, and resistant to single correct answers, thereby triggering the inquiry behaviours PBL is designed to cultivate (Hmelo-Silver, 2004; Segredo-Morales et al., 2024).

In operational terms, a strong problem brief specifies five elements: the industry context and stakeholder, the open-ended challenge statement, the expected deliverable, the time frame, and the assessment criteria. A typical vocational implementation allocates six to eight weeks per cycle, allowing sufficient depth without displacing the technical curriculum. Instructors should maintain an alignment matrix mapping each brief to the learning outcomes of both the entrepreneurship course and the students' specialization, ensuring that the project simultaneously advances entrepreneurial and disciplinary competence. Co-design meetings with industry partners at the start of each semester keep briefs current with real workplace problems and secure partner commitment to mentoring and final assessment (Bauer et al., 2025; Widiastuti et al., 2025).

Digital Resource Orchestration

Before inquiry begins, instructors curate the digital ecosystem students will need: business simulation platforms, collaborative workspaces, business-model canvassing software, data sources, and communication channels (Chen et al., 2021; Fox et al., 2018). The evidence that facilitating conditions and self-efficacy drive technology use (Venkatesh et al., 2003) implies that orchestration must include onboarding: short tool clinics, exemplars, and low-stakes practice tasks that build confidence before high-stakes project work. Institutional investment in virtual simulation training bases, as promoted in Chinese vocational education policy, supports this stage at scale (Ministry of Education of the People's Republic of China, 2022; Zhang & Huang, 2023).

Orchestration should also address equity and readiness. Not all students arrive with equal device access, connectivity, or prior digital experience, and unaddressed disparities translate directly into unequal engagement and performance. Practical measures include institution-provided devices or laboratory access hours, offline-capable resources, and diagnostic self-assessments at course entry that allow instructors to target support. Teacher readiness is equally important: instructors require hands-on familiarity with every platform students will use, and departments should schedule internal training before each delivery cycle (Alenezi et al., 2023; García-Morales et al., 2021). Finally, tool selection should favour a small, stable core set used deeply over a large, rotating set used superficially, because sustained use is what builds the self-efficacy that drives continued engagement (Venkatesh et al., 2003).

Guided Inquiry and Prototyping

Students work in teams through cycles of research, analysis, and artefact development, with instructors acting as facilitators and industry mentors providing situated feedback (Widiastuti et al., 2025; Santoso et al., 2023). Scaffolding is critical: rubrics, milestone check-ins, and structured team roles prevent the cognitive overload that unsupported PBL can produce (Boelt et al., 2022). Digital tools are used as professionals use them, namely for market research, financial modelling, prototyping, and project management, so that technology engagement becomes intrinsic to task completion rather than an add-on (Secundo et al., 2021; Dabbous & Boustani, 2023).

A workable milestone structure for a seven-week cycle is as follows: weeks one and two are devoted to problem analysis and market research, concluding with a documented problem definition; weeks three to five cover solution development and prototyping, punctuated by two mentor feedback sessions; week six is reserved for testing, refinement, and rehearsal; and week seven hosts the final presentation and assessment. Team roles such as project lead, research lead, finance lead, and design lead rotate across cycles so that every student experiences each function. Instructors monitor progress through the digital workspace itself, reviewing shared documents, version histories, and simulation logs, which provides authentic evidence of individual contribution and reduces free-riding (Boelt et al., 2022; Santoso et al., 2023).

Authentic Assessment

Assessment centres on the artefacts and performances the project generates: pitch presentations to mixed academic–industry panels, digital business plans, working prototypes, and simulation results. Competency-based rubrics aligned with frameworks such as EntreComp make entrepreneurial learning outcomes explicit and assessable (Bacigalupo et al., 2016; Colombelli et al., 2022). Embedding digital competencies within the assessment criteria signals their importance and reinforces the behavioural pathway identified in the source study (Qin & Kamrozzaman, 2026; Elmessiry et al., 2024).

A defensible rubric for vocational entrepreneurship projects typically weights five dimensions: opportunity analysis and problem understanding (twenty percent), feasibility and business logic (twenty percent), quality of the digital artefact or prototype (twenty-five percent), teamwork and process evidence drawn from the digital workspace (fifteen percent), and communication and pitch quality (twenty percent). Panels should combine the course instructor, a colleague from the students' specialization, and an industry representative, with moderation meetings to align standards across panels. Formative assessment matters as much as summative: milestone feedback delivered through the same digital platforms students work in closes the loop quickly and models professional review practices (Bacigalupo et al., 2016; Colombelli et al., 2022).

Reflection and Transfer

The cycle closes with structured reflection that converts experience into transferable capability, consistent with experiential learning theory (Kolb, 1984). Reflection prompts should explicitly connect project experiences to students' intended occupations and to future entrepreneurial opportunities, strengthening the career-integration mechanism the evidence highlights (Green & du Plessis, 2023; Decker-Lange et al., 2024). Digital portfolios provide a natural vehicle: students curate artefacts, feedback, and reflections into records they can present to employers, sustaining motivation for continued technology-mediated learning (Kamrozzaman et al., 2020).

Effective reflection is structured rather than free-form. Useful prompts include: which digital tools proved most valuable and why; what would you do differently in the next iteration; which entrepreneurial competencies did you demonstrate, with evidence; and how could this project experience apply in the occupation you are training for. Responses feed a cumulative digital portfolio comprising the problem brief, key artefacts, mentor feedback, the final pitch recording, and the reflection itself. Portfolios serve three purposes simultaneously: they consolidate learning, they provide employers with authentic evidence of capability, and they supply programme teams with rich data for continuous improvement of subsequent cycles. The cycle then restarts with a more ambitious brief, progressively transferring responsibility for opportunity identification from instructor to student.

Implementation Challenges and Mitigation Strategies

Translating the framework into routine practice will encounter predictable obstacles, and anticipating them is part of responsible implementation guidance. Table 2 summarises six recurrent challenges reported in the PBL, PjBL, and vocational digitalisation literatures, together with mitigation strategies consistent with the evidence reviewed in this paper (Boelt et al., 2022; Alenezi et al., 2023; García-Morales et al., 2021; Widiastuti et al., 2025).

Table 2. Common implementation challenges and mitigation strategies

Challenge	Description	Mitigation strategy
Instructor readiness	Facilitation of PBL and PjBL requires skills that differ from lecturing; many instructors lack experience with the digital platforms involved.	Structured professional development, co-teaching in early cycles, internal communities of practice, and tool training before each delivery cycle.
Assessment workload	Authentic assessment of artefacts, pitches, and process evidence is more time-intensive than examination marking.	Shared rubrics, panel-based assessment, peer and self-assessment components, and reuse of digital workspace evidence.
Unequal digital access	Students differ in device ownership, connectivity, and prior digital experience, risking unequal engagement.	Institution-provided devices and laboratory hours, offline-capable resources, entry diagnostics, and targeted onboarding support.
Partner sustainability	Industry partners may disengage after initial enthusiasm, cutting off the supply of authentic problems and mentors.	Formal memoranda of understanding, rotating partner pools, clear low-burden roles, and visible recognition of partner contributions.
Free-riding in teams	Unequal contribution within project teams can distort learning and grades.	Rotating defined roles, individual reflection components, contribution logs from version histories, and peer evaluation.
Curriculum time constraints	Project cycles compete with dense technical curricula for contact hours.	Six-to-eight-week bounded cycles, integration of project outcomes with specialization learning outcomes, and credit recognition.

Two of these challenges deserve elaboration. First, instructor readiness is the binding constraint in most implementations: without confident facilitators, well-designed briefs and well-provisioned platforms remain unused. Evidence from vocational teacher education shows that instructors who experience scaffolded, cooperative problem-based learning themselves are substantially more willing and able to enact it with their own students, suggesting that professional development should itself follow the PBL format rather than a lecture format (Widiastuti et al., 2025). Second, assessment workload is the most common reason experiential designs are quietly abandoned after initial pilots. The mitigation is structural rather than heroic: rubrics shared across sections, panels that distribute the marking load, and the systematic reuse of process evidence already captured in digital workspaces keep the marginal cost of authentic assessment manageable (Colombelli et al., 2022).

Institutions should also plan for iteration. First cycles rarely run smoothly, and premature judgements based on pilot friction can kill promising designs. A realistic adoption pathway spans three semesters: a pilot in one module with volunteer instructors, a refined second cycle incorporating pilot lessons, and a scaled third cycle with department-wide rubrics and partner agreements. Monitoring should track the behavioural indicators identified in the evidence, namely the frequency and depth of student technology engagement, artefact quality, and competency attainment, because these leading indicators respond to design changes faster than end-of-programme performance measures (Qin & Kamrozzaman, 2026; Venkatesh et al., 2003).

RECOMMENDATIONS

For Instructors

Instructors should redesign at least one core entrepreneurship module per programme around the five-stage cycle, beginning with a single authentic problem sourced from a local industry partner. Facilitation skills deserve deliberate development: questioning techniques, milestone feedback, and team-conflict mediation differ substantially from lecturing and are decisive for PBL quality (Hmelo-Silver, 2004; Widiastuti et al., 2025). Instructors should also model professional tool use, demonstrating, for instance, how a business-model canvas evolves in response to simulated market data, because observed usefulness is a powerful driver of student adoption (Davis, 1989; Chen et al., 2021).

A pragmatic starting sequence for an individual instructor is: select one existing module and replace one content unit with a single seven-week project cycle; recruit one industry contact willing to supply a brief and attend the final pitch; choose three core digital tools students will use throughout; and adopt the five-dimension rubric described above. After the first cycle, review the digital workspace evidence with colleagues to identify where students struggled, and adjust scaffolds accordingly. Joining or forming a community of practice with other entrepreneurship instructors accelerates this learning curve considerably, as does documenting each cycle in a short teaching case that can be shared across departments (Widiastuti et al., 2025; Pei et al., 2023).

For Curriculum Designers

Curriculum designers should embed digital content, technology-supported pedagogy, and competency-based assessment as integrated design requirements rather than optional enrichments, reflecting the significant curriculum-to-technology pathway in the evidence (Qin & Kamrozzaman, 2026). Course documents should specify which digital tools students will master, in which project contexts, and against which assessment criteria. Progression matters: early modules can rely on structured simulations, while capstone modules should require open-ended venture projects with real or semi-real stakeholders (Lackéus, 2020; Santoso et al., 2023). Interdisciplinary project templates that pair entrepreneurship outcomes with specialization outcomes operationalise the integration construct that moderates technology engagement (Huang et al., 2024; Liu et al., 2024).

Constructive alignment should govern the redesign: intended learning outcomes, project activities, digital tools, and assessment criteria must reference one another explicitly in course documents. Designers should map programme outcomes against a recognised competence framework such as EntreComp, identifying which competences each project cycle develops and assesses, so that coverage is systematic rather than accidental (Bacigalupo et al., 2016). Credit weighting also signals priorities: when project cycles carry meaningful credit and appear on transcripts, students allocate effort accordingly. Finally, designers should build progression across the programme, moving from tightly scaffolded simulated problems in the first year, through industry-commissioned briefs in the second year, to open venture creation or work-integrated projects in the final year (Lackéus, 2020; Santoso et al., 2023).

For Institutional Leaders and Policymakers

Institutional leaders should treat digital learning infrastructure, including simulation platforms, maker spaces, and cloud collaboration environments, as core entrepreneurship education provision and align investment with the national push toward virtual training bases in vocational education (Ministry of Education of the People's Republic of China, 2022; Zhang & Huang, 2023). Formal industry partnership agreements should guarantee a pipeline of authentic problems, mentors, and assessment panellists (Alenezi et al., 2023; Bauer et al., 2025). Professional development schemes should certify instructors in technology-enhanced PBL and PjBL facilitation, and workload models should recognise the coaching intensity these pedagogies demand (García-Morales et al., 2021; Zhao & Watterston, 2021). Finally, quality assurance should monitor not only satisfaction but behavioural indicators such as frequency and depth of tool use, artefact quality, and competency attainment, because these are the mechanisms through which performance is generated (Venkatesh et al., 2003; Qin & Kamrozzaman, 2026).

Leaders should institutionalise the model through three instruments. First, resource commitments: multi-year budget lines for platform licences, device pools, and partner engagement, rather than one-off project funds that expire with pilots. Second, human resource policy: recognition of PBL and PjBL facilitation in workload models, promotion criteria, and teaching awards, so that pedagogical innovation is career-enhancing rather than career-neutral. Third, governance: a standing industry advisory board per faculty that reviews briefs annually, a quality dashboard reporting the behavioural indicators described above, and periodic external review of assessment standards. Institutions in other emerging economies and technology-driven education systems can adapt the same instruments, adjusting partner structures and platform choices to local conditions (Zhang & Huang, 2023; Bauer et al., 2025; Iwu et al., 2024).

DISCUSSION

The framework advanced here reframes a structural finding as a pedagogical instruction. If digital technology use is the central behavioural pathway linking educational inputs to entrepreneurship education performance, then pedagogy must be organised to make technology engagement necessary, supported, and meaningful. PBL and PjBL achieve this by construction: authentic problems cannot be solved, and venture artefacts cannot be produced, without sustained tool use (Raimundo & Rosário, 2024; Guo et al., 2020). This interpretation converges with reviews showing that learning gains in digital entrepreneurship education stem from pedagogical integration rather than tool provision (Chen et al., 2021; Sitaridis & Kitsios, 2024), and with evidence that challenge- and venture-based formats outperform lighter experiential formats (Lackéus, 2020; Colombelli et al., 2022).

The moderation finding carries a distinctive implication for vocational education. Integration of specialization and entrepreneurship did not directly raise performance; instead, it amplified the effect of practice on technology engagement (Qin & Kamrozzaman, 2026). Pedagogically, this means integration should be designed into practice activities, through discipline-anchored problems and industry mentors, rather than delivered as standalone integration courses. This resolves apparently inconsistent findings on integration initiatives (Huang et al., 2024; Liu et al., 2024) and matches the vocational education literature's emphasis on career-relevant authenticity (Green & du Plessis, 2023; Bauer et al., 2025).

The framework also connects to wider currents in learner-centred digital pedagogy. Research on heutagogy demonstrates that technology-mediated environments can progressively shift responsibility for learning design toward learners themselves, cultivating the self-determination that entrepreneurship ultimately requires (Kamrozzaman et al., 2020; Kamrozzaman, 2025). The five-stage cycle can be read as a scaffolded pathway toward such self-determined learning: instructor-framed problems in early iterations give way to student-identified opportunities in capstone projects. Emerging technologies such as generative artificial intelligence, immersive simulation, and learning analytics will intensify this trajectory, though their adoption must be managed deliberately, given documented student challenges in using such tools productively (Jie & Kamrozzaman, 2024; Katsanakis et al., 2024).

Contextual Boundary Conditions and Transferability

The evidence supporting this framework was generated within a single provincial system, and the limits this places on generalisation should be stated rather than assumed away. Zhejiang is among the more digitally advanced provinces in China, characterised by dense small and medium enterprise activity, a mature e-commerce ecosystem, and vocational colleges that have benefited from sustained national investment in smart-campus infrastructure and virtual simulation training bases (Ministry of Education of the People's Republic of China, 2022; Zhang & Huang, 2023). Each of these conditions plausibly raises both the supply of authentic industry problems and the baseline level of student technology engagement. A vocational college situated in a region with thinner partnership networks, weaker connectivity, or a more examination-centred assessment culture should not expect the reported effect sizes to reproduce unchanged, and should treat the estimates in Table 1 as an upper reference rather than a general expectation.

It is nonetheless useful to distinguish what is likely to travel from what is not. The behavioural mechanism at the core of the framework is not specific to Zhejiang: purposeful tool use mediates learning outcomes because problems cannot be solved and artefacts cannot be produced without it, a claim grounded in general technology adoption and experiential learning theory rather than in local conditions (Davis, 1989; Venkatesh et al., 2003; Kolb, 1984). The sequencing logic of the five stages, and the requirement that each stage supply the experience, reflection, conceptualisation, and experimentation that the learning cycle demands, are similarly generic. What is context-dependent is the resource intensity at which each stage can be operated: the supply of partners, the sophistication of available platforms, the discretionary hours in the timetable, and the regulatory latitude in assessment. Table 3 separates these two layers and specifies the adaptation required when the assumed conditions do not hold.

Table 3. Contextual assumptions of the framework and adaptations for different vocational systems

Design element	Assumed condition in the source context	Adaptation where the condition does not hold
Industry co-designed problem briefs	A dense regional ecosystem of small and medium enterprises and e-commerce firms willing to supply briefs, mentors, and assessment panellists.	Where partner density is low, substitute alumni entrepreneurs, public-sector and community service problems, or a curated case bank shared across colleges in a regional consortium.
Digital resource orchestration	Institutional access to simulation platforms, smart-campus systems, and reliable connectivity, supported by national investment.	Reduce to a minimal free core, such as spreadsheet-based financial modelling, open business-model canvas templates, and a single cloud workspace; schedule laboratory access hours and prioritise depth of use over the number of platforms.
Seven-week project cycle	Timetables containing sufficient discretionary contact hours alongside the technical curriculum.	Compress to a four-week single-artefact cycle, or distribute the five stages across two linked modules, where technical curricula are more prescriptive.
Panel-based authentic assessment	Availability of external assessors and institutional acceptance of non-examination assessment.	Where regulation mandates written examinations, run the project as a weighted coursework component and use recorded pitches and digital artefacts for external moderation.
Career-integration mechanism	Clear occupational pathways connecting each specialization to identifiable local labour market demand.	Where graduate destinations are more diffuse, anchor briefs in transferable sector clusters rather than in single occupations.
Behavioural quality indicators	Digital workspaces that automatically log activity, version histories, and simulation use.	Substitute structured team logbooks, milestone artefacts, and mentor records as process evidence where learning analytics are unavailable.

The framework should therefore be read as portable in its logic and adjustable in its parameters. Institutions considering adoption are advised to conduct a short readiness audit across the four context-dependent dimensions in Table 3, namely partner supply, digital access, available contact hours, and assessment regulation, and to calibrate cycle length, tool set, and assessment format accordingly before committing to a full implementation (Bauer et al., 2025; Green & du Plessis, 2023). Transferability is, in the end, an empirical question rather than a matter of argument: whether the mediated pathways hold under varying resource constraints can be tested directly through multi-site replication with measurement invariance testing, which is the second phase of the validation agenda set out below.

Theoretical Implications

Theoretically, the paper advances entrepreneurship education research in three ways. First, it demonstrates how technology adoption theory and experiential learning theory can be combined into a single instructional logic: adoption theory explains why students engage with tools, while experiential theory explains how that engagement becomes competence. Second, it reframes digital technology use from an outcome or a context variable into a designable mediator, giving pedagogical research a concrete target: interventions should be evaluated by how much meaningful technology engagement they generate, not only by end-of-course performance. Third, it clarifies the theoretical status of integration constructs in vocational settings: integration operates as a contextual amplifier of practice rather than an independent cause of performance, a specification that future models of entrepreneurship education in technical and vocational education and training should incorporate (Qin & Kamrozzaman, 2026; Sitaridis & Kitsios, 2024).

Practical Implications

Practically, the framework gives each stakeholder group a distinct point of leverage. Instructors control problem framing, facilitation quality, and assessment design, the elements that determine whether technology engagement is necessary and supported. Curriculum designers control alignment, progression, and credit structures, the elements that determine whether engagement is systematic across a programme. Institutional leaders control infrastructure, partnerships, workload policy, and quality assurance, the elements that determine whether engagement is sustainable at scale. Because the five-stage cycle assigns responsibilities explicitly, it can serve as a shared planning artefact in programme review meetings, accreditation submissions, and industry partnership negotiations. Colleges outside China facing similar digital economy pressures can adopt the cycle with local adjustments, since none of its mechanisms depends on features unique to the Chinese system (Bauer et al., 2025; Green & du Plessis, 2023).

A Proposed AgendafFor Empirical and Longitudinal Validation

Because the five-stage cycle was derived from the structural evidence rather than tested by it, its central claims remain propositions. Stating them formally converts a plausible design into a falsifiable one. Three propositions follow directly from the framework. First, students taught through the technology-enhanced PBL–PjBL cycle will demonstrate higher digital technology engagement and stronger entrepreneurial competence than comparable students taught through conventional delivery. Second, the advantage will be largest where problem briefs are anchored in students' specializations and in real industry problems, reproducing at the level of intervention the moderation observed at the level of survey data. Third, competence gains will persist beyond the course and manifest in graduate employment quality and venture activity. None of these propositions is established by the present paper.

Table 4 sets out a staged programme through which they can be examined. The sequence is deliberate. Design-based work comes first because experiential designs commonly fail in delivery rather than in conception, and an evaluation conducted before implementation fidelity is stable would test the delivery rather than the design (Boelt et al., 2022; Widiastuti et al., 2025). Quasi-experimental comparison then supplies the causal claim that cross-sectional modelling cannot, multi-site replication establishes the geographic and institutional scope of that claim, and longitudinal tracking tests the career-transfer mechanism proposed in Stage 5 of the framework (Decker-Lange et al., 2024; Duong, 2022). Cost and scalability appraisal runs alongside the later phases, because a pedagogy that works but cannot be sustained within ordinary workload and budget constraints will not survive beyond its pilot (Iwu et al., 2024).

Table 4. Staged agenda for empirical and longitudinal validation of the proposed framework

Phase	Design and sample	Primary measures and time horizon
Phase 1. Design-based refinement	Two to three iterative delivery cycles in one institution, with instructor and student feedback and design revision after each cycle.	Implementation fidelity, frequency and depth of technology engagement, artefact quality, instructor workload. One academic year.
Phase 2. Quasi-experimental comparison	Nonequivalent control-group design comparing sections taught through the five-stage cycle with conventionally taught sections, using pre- and post-measurement with covariate adjustment.	EntreComp-aligned competence, entrepreneurship education performance, digital technology use, rubric-scored artefacts. One semester per cohort.
Phase 3. Multi-site replication	Parallel implementation across at least three provinces and two national vocational systems, analysed through multi-group structural modelling with measurement invariance testing.	Invariance of the mediated and moderated paths, moderation by institutional resource level and partner density. Two years.
Phase 4. Longitudinal graduate tracking	A single cohort followed at 12, 24, and 36 months after graduation, supplemented by employer evaluations where accessible.	Employment quality, venture creation and survival, sustained professional use of digital tools. Three years.
Phase 5. Cost and scalability appraisal	Implementation-cost and workload analysis conducted alongside Phases 2 and 3.	Staff hours per cycle, platform licensing costs, assessment load, partner retention rates. Concurrent.

Two measurement requirements apply across all phases. Outcome assessment should combine self-report with objective indicators, including platform activity logs, rubric-scored artefacts, external panel ratings, and administrative employment records, so that the common-method concerns attaching to the source evidence are not carried forward into the evaluation of the framework itself. Implementation fidelity should also be recorded systematically, using observation protocols and instructor logs, so that null results can be attributed to the design rather than to its delivery. Studies adopting the framework are encouraged to report the readiness-audit profile described in Table 3 alongside their results, since accumulating such profiles across sites is what will eventually reveal the resource thresholds below which the mediated pathways cease to operate.

Limitations and Future Research

Three sets of limitations qualify the contribution. The first concerns the evidence base. The structural results informing the framework are cross-sectional and self-reported, drawn from vocational colleges in a single Chinese province, and although procedural remedies were applied, common method variance cannot be excluded. Cross-sectional modelling also cannot settle the direction of influence: it is possible that higher-performing students engage more readily with digital tools rather than, or in addition to, technology engagement raising performance. The regional concentration of the sample is a further constraint, and for the reasons set out in Table 3 the reported estimates should be treated as specific to a comparatively well-resourced and industrially dense setting.

The second set concerns the framework. It has not been experimentally evaluated, and its operational parameters are reasoned defaults rather than optimised values. The seven-week cycle length, the five-dimension rubric weightings, and the recommendation of a small core tool set are drawn from the implementation literature and from practical judgement about vocational timetables; none has been compared against alternatives under controlled conditions. The framework additionally assumes a sustained supply of industry partners and a level of instructor facilitation capability that many institutions will need to build, and no evidence is offered here on the cost of doing so or on retention of the model beyond an initial pilot.

The third set concerns scope. The paper addresses pedagogical design and says little about accreditation regimes, funding models, or labour market structures, all of which shape what vocational colleges can implement. Beyond the validation agenda in Table 4, several questions merit direct attention: whether problem-based and project-based variants of the cycle produce different competence profiles; what dosage of experiential learning across a programme is sufficient; which formats of instructor professional development most reliably produce confident facilitation; and how rapidly evolving tools, particularly generative artificial intelligence, should be positioned within Stages 2 and 3 given documented student difficulties in using them productively (Jie & Kamrozzaman, 2024; Katsanakis et al., 2024).

CONCLUSION

This paper translated empirical evidence on technology-mediated entrepreneurship education into an

actionable pedagogical framework for vocational colleges. The evidence indicates that curriculum, practice, and specialization–industry integration improve entrepreneurship education performance chiefly by stimulating students' engagement with digital technology, and that this engagement is strongest when practice is embedded in career-relevant contexts. Problem-based and project-based learning provide the pedagogical architecture through which these mechanisms can be deliberately engineered. The proposed five-stage cycle of problem and project framing, digital resource orchestration, guided inquiry and prototyping, authentic assessment, and reflection and transfer offers instructors, curriculum designers, and institutional leaders a coherent blueprint for designing technology-enhanced entrepreneurship education that is digitally supported, practice-oriented, and career-aligned. As vocational systems worldwide confront the demands of the digital economy, such integrated pedagogical designs will be central to producing graduates who can convert entrepreneurial knowledge into entrepreneurial action. The cycle is offered as a testable blueprint rather than a finished prescription: its contextual assumptions are made explicit in Table 3, and the staged programme in Table 4 sets out how its claims can be confirmed, bounded, or overturned.

The broader message of this paper is that evidence and pedagogy must be developed together. Structural models identify which mechanisms matter; pedagogical frameworks specify how to activate them; and implementation guidance anticipates the organisational conditions under which activation succeeds or fails. Treating any one of these layers in isolation produces either evidence without application or practice without warrant. By moving deliberately from a validated structural model, through design principles, to a staged implementation cycle with explicit mitigation strategies, this paper offers vocational entrepreneurship educators a complete chain from evidence to classroom action, and invites future research to test, refine, and extend each link in that chain.

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