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TPACK Readiness, Innovative Learning Design, and Digital Entrepreneurship Skills among Indonesian Business Education Students

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Abstract

Background: Digital entrepreneurship skills are increasingly important for business graduates, but evidence remains limited on how technology-integrated pedagogy is associated with their development.
Objective: This study examined the structural associations among TPACK readiness, Innovative Learning Design, and the latent construct Digital Entrepreneurship Skills, including whether Innovative Learning Design carried a significant indirect association.
Methods: A cross-sectional survey was analyzed using covariance-based structural equation modeling. Of 119 responses, two cases met the prespecified extreme-score rule and were excluded, producing an analytic sample of 117 students. Nineteen dimension-level indicators represented the three constructs.
Results: The retained measurement model produced standardized loadings of 0.459-0.812 and composite reliability of 0.738-0.863. Model fit improved after two theoretically justified within-construct residual correlations but remained below conventional benchmarks: chi-square (114) = 308.66, $p < 0.001$; CFI = 0.808; TLI = 0.771; and RMSEA = 0.121. The three direct paths were significant: TPACK-Innovative Learning Design (beta = 0.861, $p < 0.001$), Innovative Learning Design-Digital Entrepreneurship Skills (beta = 0.451, $p = 0.044$), and TPACK-Digital Entrepreneurship Skills (beta = 0.464, $p = 0.048$). The indirect effect was not significant (beta = 0.388, $p = 0.063$).
Conclusion: The findings support significant cross-sectional associations among the constructs but do not support the proposed mediation hypothesis. Interpretation should remain cautious because of suboptimal model fit, the single-institution sample, and the cross-sectional, self-report design.

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INTRODUCTION

Digital technology has reshaped the global economic landscape and expanded opportunities commonly described as digital entrepreneurship or digital venturing. Indonesia's digital economy illustrates this shift: gross merchandise value was projected to reach approximately USD 104 billion by 2025, positioning the country among Southeast Asia's largest digital markets (Google, Temasek, & Bain & Company, 2022). National policy documents continue to treat wider entrepreneurship participation and digital transformation as priorities (Kementerian Koperasi dan UKM, 2023). Rather than relying on an unverified national estimate

of student entrepreneurship, the present study focuses on the measurable learning conditions and skills reported by a defined university-course cohort.

The educational challenge is not simply access to technology but the capacity to connect technological knowledge with pedagogical strategy and entrepreneurship content. Digital entrepreneurship requires students to recognize opportunities, communicate through digital channels, manage e-business activities, and adapt to changing platforms. These capabilities provide a direct conceptual link to TPACK: technological, pedagogical, and content knowledge can jointly inform the design of learning activities through which students practice those capabilities. The present study therefore examines this instructional linkage within the observed course setting rather than making unsupported population-level claims about Indonesian students.

Higher education institutions are increasingly called upon to close this gap. Indonesia's Making Indonesia 4.0 roadmap and the long-term vision of "Indonesia Emas 2045" both identify technologically competent, entrepreneurially capable human capital as a national priority, echoing UNESCO's (2024) call for education systems to adapt to future labor-market demands centered on digital and entrepreneurial competencies. At the level of classroom practice, however, translating this policy ambition into an actionable instructional design remains difficult. The Technological Pedagogical Content Knowledge (TPACK) framework, which conceptualizes effective technology-integrated teaching as the intersection of technological, pedagogical, and content knowledge Mishra & Koehler (2006), offers a theoretically grounded starting point, since it explicitly addresses how technology, teaching strategy, and subject-matter content can be woven together rather than treated as separate competencies (Koehler & Mishra, 2009).

Despite the conceptual fit between TPACK and digital entrepreneurship education, the two literatures have developed largely in parallel. Existing TPACK research in Indonesia has concentrated on K-12 numeracy outcomes, learning-device development, or pre-service teacher readiness (Widaningsih et al., 2023). Digital entrepreneurship research, by contrast, has focused mainly on antecedents of entrepreneurial intention rather than on instructional design for skill development (Susanto et al., 2023). Bringing these strands together is theoretically relevant because TPACK specifies the knowledge integration needed to design technology-supported instruction, whereas digital entrepreneurship education specifies the applied business capabilities that such instruction seeks to cultivate.

This study addresses that gap by testing a structural model derived from the Analysis and Design stages of a broader ADDIE-based Research and Development (R&D) project (Branch, 2009). The present cross-sectional component examines whether TPACK readiness is associated with business education students' Digital Entrepreneurship Skills directly and indirectly through Innovative Learning Design. Specifically, the study tests whether (1) TPACK readiness is positively associated with Innovative Learning Design, (2) Innovative Learning Design is positively associated with Digital Entrepreneurship Skills, (3) TPACK readiness is directly associated with Digital Entrepreneurship Skills, and (4) the indirect association through Innovative Learning Design is statistically significant. The analysis therefore evaluates structural associations, not temporal prediction or causal influence. Lowercase digital entrepreneurship skills denotes the general competence domain; title case Digital Entrepreneurship Skills denotes the operationalized latent construct in this study. The study is aligned with Sustainable Development Goal (SDG) 4 on quality education and SDG 8 on decent work and economic growth.

TPACK extends Shulman's notion of pedagogical content knowledge by adding technology as a third, interacting knowledge domain (Mishra & Koehler, 2006). The framework's seven constructs, Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), and their pairwise and triple intersections (TPK, TCK, PCK, and TPACK itself), describe teaching expertise as an integrative rather than additive competence (Koehler & Mishra, 2009). A bibliometric analysis of the field found that TPACK research has grown steadily since 2011, diversifying from teacher-education contexts into disciplinary areas such as health professions education, underscoring the framework's portability across domains (Hsu, 2022); see also Ait et al. (2023) for an application in health professions education). More recently, Mishra (2006) and Petko (2025) have proposed contextualized extensions of TPACK that situate technology integration within broader institutional and cultural systems of practice, arguing that technology adoption cannot be understood independently of the context in which teaching occurs.

The COVID-19 pandemic accelerated empirical interest in TPACK as an explanatory

framework for technology-integrated teaching. Akram et al. (2021) found that pandemic-driven demands increased faculty digital competence largely irrespective of gender or teaching experience, while Akram (2022) showed that perceived usefulness and ease of technology adoption remain central drivers of acceptance in online education settings. Using a Delphi approach, Maor (2017) further demonstrated that expert consensus on TPACK-informed digital pedagogy emphasizes the deliberate design of learning activities rather than the mere presence of technology in the classroom, a distinction that is central to the present study's focus on "innovative learning design" as an intermediate construct between TPACK knowledge and applied skill outcomes.

Digital entrepreneurship education has become an increasingly prominent stream within entrepreneurship research (Sitaridis & Kitsios, 2024). Ratten (2023) argues that digital business models demand a distinct pedagogical response because they require students to operate in self-organizing, scalable, and rapidly evolving environments that traditional entrepreneurship curricula were not designed to address. Consistent with this, Mirhabibi et al. (2025) found that business students' digital entrepreneurship readiness is shaped by the moderating roles of digital mindset and digital education, concluding that conventional instruction is, on its own, insufficient preparation for digital venture creation. Several studies have examined the cognitive and motivational antecedents of digital entrepreneurial intention: Susanto et al. (2023) showed that digital entrepreneurship education influences digital entrepreneurial intention through the mediating role of entrepreneurial alertness; Abaddi (2024) reported a comparable mediating and moderating structure involving digital skills, entrepreneurship education, and entrepreneurial alertness among final-year undergraduates; and Bachmann et al. (2024) linked digital competencies directly to entrepreneurial intention. Patma et al. (2024) further found that social media exposure shapes students' entrepreneurial intention primarily through attitudes and subjective norms.

Beyond entrepreneurial intention, digital competence also has relevance for adaptation to changing labor markets. Balsmeier and Woerter (2019) show that employees with stronger digital skills are better positioned to benefit from organizational digitalization. At the institutional level, Sitaridis and Kitsios (2024) and Biedma-Ferrer et al. (2024) emphasize that universities play a central role in developing students' entrepreneurial attitudes and readiness, while project- and problem-based learning approaches can strengthen practical and innovation-oriented dimensions of entrepreneurship education (Radianto & Wijaya, 2017).

Twenty-first-century skills commonly summarized as the "4Cs" of communication, collaboration, creativity, and critical thinking have become a central reference point for curriculum reform worldwide (Lamri, Barabel, & Meier, 2023; Van Damme, Lundie, & Morris, 2024). A systematic review of Education 4.0 frameworks found that skills-dimension components (including problem-solving and social-innovation education) dominate the literature, while meta-learning frameworks such as TPACK remain comparatively underrepresented (Acosta-Gonzaga & Ramirez-Arellano, 2022). This is consistent with evidence from Indonesian secondary education showing that 4Cs competencies are often inconsistently reflected in actual teaching documentation and lesson plans, suggesting an implementation gap between curriculum intent and classroom practice (Fauziah, Suyanto, & Surbakti, 2024). Pedagogical models explicitly designed to operationalize twenty-first-century learning, such as the Learning Design Cooperative Framework, have been shown to enrich and more evenly distribute student learning opportunities when built around technology-enhanced, learner-centered activity (Lamrabet, El Janati, & El Ghazi, 2021).

A small but growing body of work suggests that TPACK-integrated instruction is relevant to both technical and entrepreneurship-related learning. Yao (2024) reported a positive association between perceived industry-education integration and learning motivation in a TPACK-informed course. The smart-learning-environment literature offers a compatible design logic: flexibility, engagement, adaptivity, and reflectiveness are central properties of technology-supported environments Singh & Hassan (2017) and Spector (2014), and these properties correspond to the Innovative Learning Design construct examined here. In digital entrepreneurship education, such design features can provide authentic opportunities to practice digital communication, opportunity recognition, e-business management, and adaptive problem-solving. Technology adoption alone is insufficient; integration also depends on coordination

among instructors, technical staff, and administrators Durff & Carter (2019) and on the combination of subject-matter and pedagogical expertise (Islam et al., 2019).

Table 1 summarizes representative prior studies at the intersection of TPACK, entrepreneurship education, and twenty-first-century skills. Three gaps emerge. First, TPACK research in Indonesia has concentrated on primary and secondary education and pre-service teacher preparation rather than university business students (Hayani & Sutama, 2022; Widaningsih et al., 2023). Second, digital entrepreneurship research has emphasized entrepreneurial intention rather than instructional design associated with skill development (Patma et al., 2024). Third, the reviewed studies did not combine TPACK, Innovative Learning Design, and Digital Entrepreneurship Skills within one measurement and structural model for business education students. This study therefore specifies three constructs: TPACK readiness; Innovative Learning Design, reflecting pedagogical innovation, technological integration, learner-centeredness, collaboration, authenticity, and reflectiveness; and Digital Entrepreneurship Skills, reflecting digital literacy, creativity, digital communication, e-business management, opportunity recognition, and adaptive problem-solving.

Table 1

Summary of representative prior studies and positioning of the present study

Study	Focus	Method	Population
Widaningsih et al. (2023)	TPACK-based learning to improve numeracy and learning outcomes	R&D	Primary school students
Kurnianto and Sarwono (2023)	TPACK-based instructional tools for problem-solving	ADDIE R&D	Secondary school students
Hayani and Sutama (2022)	TPACK devices for online learning quality	R&D	Teachers/schools
Patma et al. (2024)	Social media and entrepreneurial intention	Survey (TPB)	University students
Susanto et al. (2023)	Digital entrepreneurship education and intention via alertness	Survey	University students
Abaddi (2024)	Digital skills, education, and alertness on intention	Survey	Final-year undergraduates
Mirhabibi et al. (2025)	Digital mindset/education moderating readiness	Survey	Business students
Fauziah et al. (2024)	4Cs integration in curriculum documents	Systematic review	Secondary education
This study	TPACK-based innovative learning design and digital entrepreneurship skills, structural equation modeling and hypothesis testing	SEM (CFA + structural model)	Business education university students

Hypothesis Development

Building on the conceptual framework above, TPACK readiness is theorized as the knowledge base associated with an innovative, technology-integrated learning experience (Mishra & Koehler, 2006). Innovative Learning Design is, in turn, expected to be associated with applied Digital Entrepreneurship Skills (Gros, 2016; Ratten, 2023).

The cross-sectional model tests three direct associations and one indirect association without implying temporal causation. Accordingly, the study tests the following hypotheses:

1. H1: TPACK readiness is positively associated with Innovative Learning Design.
2. H2: Innovative Learning Design is positively associated with Digital Entrepreneurship Skills.
3. H3: TPACK readiness is directly and positively associated with Digital Entrepreneurship Skills.
4. H4 (indirect association): TPACK readiness has a statistically significant indirect association with Digital Entrepreneurship Skills through Innovative Learning Design.

METHOD

This study employed a quantitative cross-sectional design to examine structural associations among TPACK readiness, Innovative Learning Design, and Digital Entrepreneurship Skills. It constitutes one analytical component of a larger R&D project that used the ADDIE model to design a TPACK-based learning experience (Branch, 2009). The broader project supplied the conceptual framework and questionnaire developed during its Analysis and Design stages; this article does not report evaluation of the completed R&D product. It reports only the cross-sectional survey and the tests of H1-H4 using confirmatory factor analysis and structural equation modeling.

The study was conducted at Universitas Pendidikan Indonesia, Bandung, among students enrolled in an entrepreneurship course in the Business Education study program. Purposive sampling was defined by one study-relevant inclusion criterion: current enrollment in the course from which the TPACK-based learning context was observed. This criterion limits inference to the sampled course cohort and does not represent probability sampling of Indonesian university students. A total of 119 valid questionnaire responses entered preprocessing. Two cases met the prespecified extreme-score rule described below, leaving 117 cases for measurement-model and structural-model estimation.

Data were collected using a structured questionnaire with a five-point Likert response scale (1 = strongly disagree to 5 = strongly agree). Construct specification was theory based and was completed during the Analysis and Design stages of the broader project. TPACK readiness followed the seven knowledge domains of the TPACK framework (Mishra & Koehler, 2006). Innovative Learning Design reflected pedagogical innovation, technological integration, learner-centeredness, collaboration and networking, authentic learning context, and reflective and adaptive design. Digital Entrepreneurship Skills reflected digital literacy, creativity and innovation, digital communication, e-business management, opportunity recognition, and adaptability and problem-solving. For SEM, the 19 dimension-level scores were treated as observed indicators of the three latent constructs; therefore, indicator in this article refers to a dimension-level composite rather than a single questionnaire item.

Construct reliability and convergent validity were assessed using confirmatory factor analysis (CFA)-based composite reliability (CR) and average variance extracted (AVE), which are generally considered more appropriate than Cronbach's alpha within a latent-variable modeling framework because they account for the actual factor loading of each indicator rather than assuming equal indicator weighting. These estimates are reported alongside the measurement model in Section 4.1.

Hypothesis testing used covariance-based structural equation modeling (CB-SEM). All 119 responses entered preprocessing. The 19 dimension-level scores were converted to z scores to place the observed composites on a common metric and to support transparent extreme-score inspection; the transformation preserved their relative ordering and was not used as a substitute for validity assessment. The prespecified screen flagged a case when any standardized dimension score exceeded an absolute value of 3. This was an indicator-level extreme-score rule, not a multivariate-distance diagnostic. Two cases met the rule, yielding the final analytic sample of n = 117.

Model estimation followed the two-step approach of (Anderson and Gerbing, 1988). First, a three-construct confirmatory factor analysis was estimated. Content Knowledge and Technological Pedagogical Knowledge were removed because their loadings were statistically non-significant and inconsistent with the retained TPACK dimensions. This modification improved the empirical specification but does not prove the theoretical TPACK structure. Second, the structural model estimated the three direct paths specified in H1-H3. The initial model was below conventional fit thresholds. Modification indices were then considered only for theoretically defensible within-construct pairs; residual correlations were added between Technological Content Knowledge and integrated TPACK and between E-Business Management and Adaptability/Problem-Solving before re-estimation.

Model fit was evaluated using chi-square, CFI, TLI, RMSEA, and GFI. The indirect association in H4 was assessed with a Sobel test. Because all constructs were measured through one self-report questionnaire on one occasion, common-method bias could inflate observed associations; this risk is considered in the limitations, and no unreported post hoc common-

method test is claimed. Analyses were conducted in Python using semopy with maximum likelihood estimation.

RESULTS AND DISCUSSION

Results

Measurement Model (Confirmatory Factor Analysis)

A three-factor CFA was estimated on the analytic sample (n = 117). Content Knowledge and Technological Pedagogical Knowledge had non-significant, inconsistent loadings and were removed from the retained measurement model reported in Table 2. Their removal represents empirical model respecification and should not be interpreted as proof of the theoretical TPACK structure. All retained standardized loadings were statistically significant ($p < 0.001$) and ranged from 0.459 to 0.812. Composite reliability exceeded 0.70 for all constructs. AVE exceeded 0.50 only for Innovative Learning Design and remained below 0.50 for TPACK readiness and Digital Entrepreneurship Skills; therefore, construct reliability was adequate, whereas convergent validity was only partially supported.

Table 2

Standardized measurement model (CFA) results (n = 117)

Construct / Indicator	Standardized Loading	z-value	p
TPACK Framework (CR = 0.738, AVE = 0.368)			
Technological Knowledge (TK)	0.565	— (ref.)	—
Pedagogical Knowledge (PK)	0.779	5.81	< 0.001
Technological Content Knowledge (TCK)	0.535	4.56	< 0.001
Pedagogical Content Knowledge (PCK)	0.459	4.08	< 0.001
Integrated TPACK	0.644	5.21	< 0.001
Innovative Learning Design (CR = 0.863, AVE = 0.513)			
Pedagogical Innovation (PI)	0.612	— (ref.)	—
Technological Integration (TI)	0.710	6.24	< 0.001
Learner-Centeredness (LC)	0.673	6.00	< 0.001
Collaboration and Networking (CN)	0.721	6.31	< 0.001
Authentic Learning Context (AUC)	0.754	6.51	< 0.001
Reflective and Adaptive Design (RAD)	0.812	6.85	< 0.001
Digital Entrepreneurship Skills (CR = 0.823, AVE = 0.441)			
Digital Literacy (DL)	0.797	— (ref.)	—
Creativity and Innovation (CI)	0.677	7.46	< 0.001
Digital Communication (DC)	0.772	8.72	< 0.001
E-Business Management (EBM)	0.594	6.41	< 0.001
Opportunity Recognition (OR)	0.542	5.81	< 0.001
Adaptability and Problem-Solving (APS)	0.560	6.00	< 0.001

Model Fit and Respecification

The initial structural model, comprising the retained measurement model and the three direct paths, produced fit indices below conventional thresholds (CFI = 0.775; TLI = 0.736; RMSEA = 0.130). Two within-construct indicator pairs showed theoretically defensible content overlap: Technological Content Knowledge with integrated TPACK, and E-Business Management with Adaptability/Problem-Solving. Allowing their residuals to correlate ($r = 0.324$, $p < 0.001$; $r = 0.202$, $p = 0.004$, respectively) improved fit: chi-square (114) = 308.66, $p < 0.001$; CFI = 0.808; TLI = 0.771; RMSEA = 0.121; and GFI = 0.732. These indices remained below commonly applied benchmarks (e.g., CFI >= 0.90 and RMSEA <= 0.08). The modest sample relative to model complexity may have contributed, but the source cannot be established from the present data. Accordingly, the respecified-model coefficients are reported as provisional associations requiring replication.

Structural Associations and Direct-Path Hypothesis Tests

Table 3 presents the standardized structural coefficients. TPACK readiness was positively

associated with Innovative Learning Design (beta = 0.861, z = 4.73, p < 0.001), supporting H1. Innovative Learning Design was positively associated with Digital Entrepreneurship Skills (beta = 0.451, z = 2.02, p = 0.044), supporting H2. TPACK readiness also had a significant direct association with Digital Entrepreneurship Skills (beta = 0.464, z = 1.98, p = 0.048), supporting H3. Thus, the three direct-path hypotheses were supported. The model accounted for 74.2% of the variance in Innovative Learning Design (R-squared = 0.742) and 78.0% in Digital Entrepreneurship Skills (R-squared = 0.780). These coefficients describe cross-sectional associations and should not be interpreted as temporal prediction or causal effects.

Table 3

Structural path estimates and hypothesis testing summary (n = 117)

Path	Std. β	z	p	Hypothesis
TPACK → Innovative Learning Design	0.861	4.73	< 0.001	H1 supported
Innovative Learning Design → Digital Entrepreneurship Skills	0.451	2.02	0.044	H2 supported
TPACK → Digital Entrepreneurship Skills (direct)	0.464	1.98	0.048	H3 supported
TPACK → ILD → Digital Entrepreneurship Skills (indirect)	0.388	1.86	0.063	H4 not supported

The Sobel test yielded a standardized indirect coefficient of 0.388 (unstandardized ab = 0.542, SE = 0.292, z = 1.86, p = 0.063). Because p exceeded the prespecified 0.05 threshold, H4 was not supported. The result does not provide sufficient evidence of mediation and should not be labeled partial mediation. Although the point estimate was positive, its uncertainty precludes concluding that Innovative Learning Design carried a statistically significant indirect association between TPACK readiness and Digital Entrepreneurship Skills in this sample.

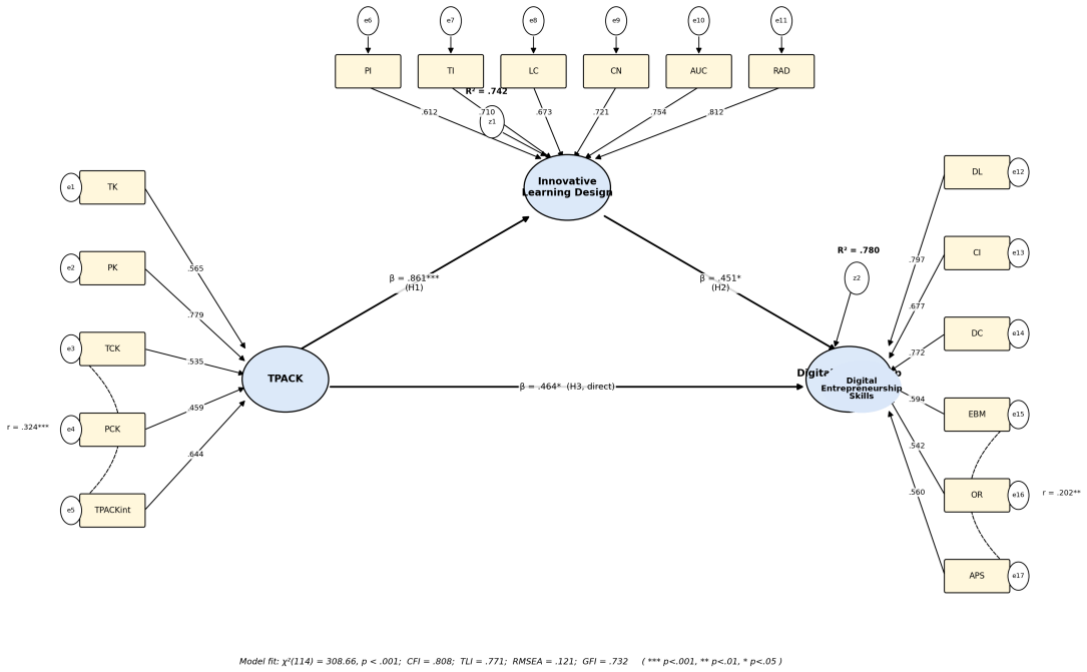


Figure 1. Final respecified structural equation model with standardized path coefficients, factor loadings, correlated measurement errors, and squared multiple correlations (n = 117).

Discussion

The structural model supported the three direct-path hypotheses (H1-H3). TPACK readiness was strongly associated with Innovative Learning Design (H1: beta = 0.861, p < 0.001). This pattern is consistent with Yao's (2024) finding that TPACK-integrated instruction is

associated with perceived learning quality and with Koehler and Mishra's (2009) account of TPACK as a knowledge base for technology-integrated pedagogical practice. In the measurement model, Pedagogical Knowledge and integrated TPACK had higher loadings than Pedagogical Content Knowledge. Within this sample, general pedagogical knowledge and integrative technological awareness therefore contributed more strongly to the measured TPACK construct. This loading pattern is sample specific and does not establish a universal hierarchy among TPACK domains.

Innovative Learning Design was positively associated with Digital Entrepreneurship Skills (H2: beta = 0.451, p = 0.044). This finding is compatible with literature emphasizing adaptivity and authentic engagement in smart learning environments Spector (2014) and with Ratten's (2023) argument that digital ventures require learning experiences beyond conventional entrepreneurship pedagogy. TPACK readiness also had a significant direct association with Digital Entrepreneurship Skills (H3: beta = 0.464, p = 0.048). However, the indirect association did not reach significance (p = 0.063); consequently, the proposed mediation was not supported. For instance, general digital literacy may be related to technological knowledge without being statistically transmitted through the full Innovative Learning Design construct. This interpretation remains tentative because the indirect estimate was uncertain and the study was cross-sectional.

Taken together, the results show that TPACK readiness, Innovative Learning Design, and Digital Entrepreneurship Skills were closely associated in the sampled course cohort. They do not establish that Innovative Learning Design is a mediating mechanism or that one construct caused change in another. The findings nevertheless suggest that curriculum development may consider technological-pedagogical integration alongside opportunities to practice digital entrepreneurship capabilities. Such implications should be treated as directions for program design and further testing, not as evidence for a particular intervention package. This cautious interpretation is consistent with Durff and Carter's (2019) view that technology-pedagogy integration depends on coordinated institutional conditions.

Limitations and Directions for Future Research

This study has several limitations. First, overall model fit remained below conventional benchmarks after theoretically guided respecification (CFI = 0.808; RMSEA = 0.121). The modest analytic sample (n = 117) relative to model complexity may have contributed, but the present evidence does not justify attributing the shortfall solely to sample size. The structural coefficients should therefore be interpreted as provisional. Second, AVE was below 0.50 for TPACK readiness and Digital Entrepreneurship Skills, so convergent validity was only partially supported. High correlations relative to the square roots of AVE also indicate limited discriminant validity. Third, removing Content Knowledge and Technological Pedagogical Knowledge reflects an empirical weakness in this instrument and does not confirm the TPACK structure.

Fourth, the sample came from one study program at one Indonesian public university, which limits generalizability. Fifth, all constructs were measured by self-report in one questionnaire on one occasion. Social-desirability, self-assessment, and common-method bias may therefore have inflated their associations. Sixth, the cross-sectional design precludes temporal and causal inference. Future studies should replicate the model with larger multi-institution samples, refine the underperforming TPACK indicators, use longitudinal or quasi-experimental designs, and incorporate objective or performance-based evidence such as evaluated business prototypes or portfolios.

CONCLUSION

This study examined a cross-sectional structural model of TPACK readiness, Innovative Learning Design, and Digital Entrepreneurship Skills among 117 business education students retained from 119 valid responses. The three direct-path hypotheses were supported: TPACK readiness was positively associated with Innovative Learning Design and Digital Entrepreneurship Skills, and Innovative Learning Design was positively associated with Digital Entrepreneurship Skills. The model accounted for 74.2% and 78.0% of the variance in the two downstream constructs. However, the indirect association was not statistically significant (p = 0.063); therefore, H4 was not supported, and no partial-mediation claim is warranted. Suboptimal

model fit and incomplete convergent and discriminant validity require cautious interpretation and independent replication.

The findings offer bounded implications rather than prescriptive evidence. Instructors and programs may consider aligning technological knowledge, pedagogy, entrepreneurship content, and authentic opportunities to practice digital business skills, but the present study does not establish the effectiveness of any specific activity, facility, or policy. Future research should test such instructional options with larger multi-institution samples, longitudinal or quasi-experimental designs, refined measures, and performance-based outcomes. These steps would determine whether the observed associations generalize and whether TPACK-informed learning design contributes to change in Digital Entrepreneurship Skills over time.

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AUTHOR CONTRIBUTION STATEMENT

Dian H. Utama, S. Sulastri, Girang Razati, and Ratu Dintha IZFS contributed to the conception, methodology, investigation, data analysis, and preparation of the manuscript. All authors approved the final manuscript.

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