Int. J. of Management, Entrepreneurship, Social Science and Humanities, Vol. 10 No. 1 (2026) https://doi.org/10.31098/ijmesh.v10i1.4618

Research Paper

A Quantitative Study of Project-Based Learning for Digital Transformation Readiness in Entrepreneurship Education

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Received : April 18, 2026	Revised : May 12, 2026	Accepted : August 20, 2026	Online : August 16, 2026

Abstract

The gap between the high interest in entrepreneurship among Indonesians and the low actual entrepreneurship rate suggests that entrepreneurship education in vocational higher education lacks an ideal curriculum-based practical model to bridge this divide while simultaneously accelerating the digital transformation of Micro, Small, and Medium Enterprises (MSMEs). This study aims to develop and evaluate a Project-Based Learning (PjBL) model integrated with an Outcome-Based Education (OBE) curriculum structure within the Digital Transformation and Technopreneurship course. A quasi-experimental approach was employed, involving 91 vocational college students in Semarang, Indonesia, over 6.5 weeks of active instruction organized into 29 groups and collaborate with 29 MSMEs. Data were analyzed using descriptive statistics. Structural Equation Modeling (SEM) was also conducted to examine the role of Project-Based Learning (PjBL) as a mediator between Entrepreneurial Support Clarity (ESC) and Digital Transformation Readiness Competency (DTRC). The study demonstrated a significant influence of PjBL in leveraging ESC ($\beta=0.525$; $p<0.001$) on DTRC. The PjBL implementation proved effective, with the proportion of students achieving an 'A' grade rising from 10.70% during the conceptual reinforcement stage to 96.40% during the real-project implementation stage. Achievement levels for course learning outcome indicators closely matched the established weightings, while Digital Readiness Assessment (DRA) results indicated that the partner MSMEs' digital maturity fell within Level 2 (Basic Digital). These findings confirm the relevance of the five PjBL criteria, as follows: centrality, driving questions, constructive investigation, autonomy, and realism, within the framework of Experiential Learning Theory. The study's novelty lies in the development of an implementation model that explicitly maps the integration of OBE, PjBL, and digital transformation instruments, offering both theoretical and practical contributions to entrepreneurship curriculum development in vocational higher education and the acceleration of MSME digital transformation in Indonesia.

Keywords: *Project-Based Learning, Outcome-Based Education, Entrepreneurial Support Clarity, Digital Entrepreneurship Capability, Digital Transformation Readiness Competency*

INTRODUCTION

Indonesian entrepreneurship faces a fundamental paradox between aspirations and realization. The Ministry of Micro, Small, and Medium Enterprises (MSMEs) notes that the national entrepreneurship ratio in 2025 reached 3.29% of the total workforce, surpassing the established target of 3.10% (Kementerian UMKM RI, 2025). That ratio still lags far behind those of developed nations like the United States, which reaches around 12%, as well as Singapore and Malaysia, which are ahead of Indonesia (Kementerian Koordinator Bidang Perekonomian RI, 2022). Ironically, this gap is not caused by a lack of interest in entrepreneurship; in fact, the Global Entrepreneurship Monitor (GEM) recorded Indonesia's perceived entrepreneurship rate at 21.6% in 2023, the highest in ASEAN, surpassing Thailand (17.8%), Vietnam (15.2%), and Malaysia (13.4%) (Jayadi,

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2025). The stark gap between perceived entrepreneurial activity (21.6%) and the actual entrepreneurship rate (3.29%) represents a fundamental issue: high interest has not yet been successfully converted into a sufficient number of realized businesses.

Higher education institutions bear a strategic responsibility to deliver a high-quality, innovative, and relevant learning process for the business and industrial sectors. The reality on the ground indicates that university graduates still face significant challenges regarding labor market absorption. According to data from Statistics Indonesia, the number of unemployed individuals in Indonesia reached 7.35 million in November 2025; graduates holding degrees accounted for an open unemployment rate of 5.38 percent, the highest figure after graduates from vocational high schools and general high schools (Statistics Indonesia, 2025). This indicates a skills mismatch and misalignment between graduate competencies and labor-market needs.

The issues of unemployment among the educated and low entrepreneurship rates cannot be separated from the responsibilities of higher education institutions, which are required to meet Key Performance Indicators (KPIs) as a measure of accountability and contribution to national and global development. Under the Decree of the Minister of Higher Education, Science, and Technology No. 358/M/KEP/2025, a key strategic indicator is KPI 7: the extent of higher education institutions' involvement in achieving the Sustainable Development Goals (SDGs) (Decree of the Minister of Higher Education, Science, and Technology No. 358/M/KEP/2025 on Key Performance Indicators for Higher Education Institutions, 2025). In the context of vocational education, contributions to the SDGs are realized not only through research and community service activities but also through the implementation of curricula and learning processes aligned with the needs of society and the business sector, specifically addressing SDG 17 (Partnerships for the Goals). A relevant form of implementation is the strengthening of partnerships with the business and/or industrial sectors, particularly Micro, Small, and Medium Enterprises (MSMEs), as integral components of the local economic ecosystem (Castellani et al., 2024; Osorno-Hinojosa et al., 2023). This imperative is underscored by the fact that, while Indonesia's more than 64 million MSMEs contribute over 60 percent of the national GDP and employ approximately 97 percent of the workforce, only about 25.5 million units (roughly 38%) had transitioned into the digital ecosystem by mid-2024 (ANTARA, 2025). This leaves a majority of MSMEs still in need of guidance to go digital. Collaborations, often implemented through PjBL, enable higher education institutions to play an active role in enhancing MSME capacity and competitiveness through knowledge-based support, while simultaneously providing students with contextual learning experiences and accelerating national MSME digitalization targets.

This gap between concept and practice is critical, given that Indonesia's current higher vocational education curriculum framework is oriented toward the Outcome-Based Education (OBE) approach. This curriculum design systematically aligns learning outcomes, instructional methods, and assessments to ensure the achievement of established outcomes (Spady, 1994). Specifically, in entrepreneurship courses, the implementation of OBE has been shown to enhance student engagement and foster academic achievements that are more applicable than those derived from purely conceptual learning (Naing & Tin, 2025; Tewari et al., 2024). Furthermore, it serves as a relevant framework for cultivating a culture of innovation and entrepreneurship within business higher education (Charrón Vías & Rivera-Cruz, 2020).

This positions partnership-based entrepreneurship education involving MSMEs as a crucial strategy for vocational higher education institutions to develop (Anatan, 2024). The model addresses a gap in the implementation of the Outcome-Based Education (OBE) curriculum by tangibly integrating entrepreneurship learning with the acceleration of MSME digital transformation, aligned with the Course Learning Outcomes (CLO) mapping. Furthermore, this study examines the influence of Entrepreneurial Support Clarity and Digital Entrepreneurship

Capability on Digital Transformation Readiness Competency, with PjBL serving as a mediating variable, to empirically demonstrate the acceleration of MSME digital transformation.

This study also contributes to the body of knowledge on Experiential Learning Theory by Kolb (1984) by operationalizing its four stages (Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation) as a structured, measurable Project-Based Learning (PjBL) intervention cycle. In this study, PjBL is not treated as a standalone instructional method but rather as a practical manifestation of the ELT cycle. Every stage of the student learning process, ranging from field experiences with MSMEs and group reflection to the conceptualization of digital solutions and active experimentation, is explicitly mapped and evaluated for its impact on Digital Transformation Readiness Competency (DTRC). PjBL bridges the conceptual gap in digital entrepreneurship education (Amalia & von Korflesch, 2021; Rauf et al., 2024) through a curriculum practice model empirically validated in real-world classroom settings. Furthermore, the study offers a measurable model for accelerating MSME digital transformation through campus partnerships, which other vocational higher education institutions can replicate. Thus, this study aims to develop an OBE-based Project-Based Learning model to enhance the effectiveness of entrepreneurship courses in higher education while accelerating MSME digital transformation in Indonesia, and to empirically test the proposed model to seek the answer to the following research question: Does PjBL mediate the relationship between Entrepreneurial Support Clarity and Digital Entrepreneurship Capability and DTRC?

LITERATURE REVIEW

This literature review discusses interconnected conceptual foundations framing the study.

Experiential Learning Theory

Experiential Learning Theory (ELT), developed by Kolb (1984), was selected as the overarching framework to bridge project-based learning and entrepreneurship education. Kolb et al. (2014) define learning as a process in which knowledge is created through the transformation of experience, resulting from a combination of grasping and transforming that experience. Within this framework, Kolb distinguishes between two forms of knowledge: explicit knowledge, acquired through language, textbooks, and formal education, and know-how (or tacit knowledge), acquired through hands-on practice and trial-and-error. In the context of entrepreneurship, know-how is often a decisive factor for success; an entrepreneur may possess deep market knowledge yet still require practical know-how to bring a product to market, a gap that can only be bridged by taking risks and making mistakes through the experiential process itself.

Entrepreneurship Education

Entrepreneurship education is a conceptual offshoot of entrepreneurship specifically oriented toward the learning context (Kuratko, 2005). While entrepreneurship focuses on entrepreneurial practices and mindsets, entrepreneurship education addresses how these values, knowledge, and skills can be transferred, practiced, and internalized by learners through a structured educational process (Chege et al., 2020; Kuratko, 2005). A mapping of the entrepreneurship education literature in Indonesian higher education reveals that the field remains dominated by conceptual and descriptive studies, whereas the number of applicable, field-tested curriculum implementation models remains relatively limited (Amalia & von Korflesch, 2021). Consequently, entrepreneurship education in vocational higher education serves a dual function: acting as an instrument to build graduate competencies adaptable to two career paths, employment and entrepreneurship, while simultaneously serving as a vehicle for the institution to make tangible contributions to local economic empowerment through partnerships with surrounding business entities.

Digital Transformation

Digital transformation is defined as a process in which digital technology creates disruption, triggering a strategic organizational response to alter value-creation pathways while simultaneously managing the accompanying structural changes and organizational barriers (Vial, 2019). For MSMEs, digital transformation is not merely a matter of instant technology adoption but a phased process that requires assessing readiness levels before devising a digitalization strategy. Control Objectives for Information and Related Technologies (COBIT), specifically the MSME Focus Area within COBIT 2019, has proven adaptable in a modular fashion for evaluating information technology governance within the context of MSMEs, serving as a concise yet structured evaluation framework (Archaqie & Pratiwi, 2025; Rashikha et al., 2024). This framework underpins the development of the Digital Readiness Assessment (DRA) instrument in this study, a staged measurement tool that maps an MSME's position along the digital maturity spectrum, ranging from a pre-digital state to an optimized digital enterprise, while also acting as a conceptual bridge between organizational-level digital transformation theory and practical field-based student mentorship.

Project-Based Learning (PjBL)

Project-Based Learning (PjBL) is a student-centered, active learning model that has been widely examined (Guo et al., 2020), particularly for its role in supporting the Outcome-Based Education (OBE) curriculum. The OBE curriculum itself is an approach that systematically aligns learning design, instructional methods, and assessment to ensure the achievement of predetermined outcomes, rather than focusing solely on the teaching process (Spady, 1994). This approach is closely linked to the implementation of PjBL. Kokotsaki et al. (2016) define PjBL as a form of student-centered active learning characterized by student autonomy, constructive investigation, goal setting, collaboration, communication, and reflection within the context of real-world practice. This definition emphasizes that PjBL is not merely a project assignment at the end of a lesson, but rather an instructional approach that places the project at the core of the learning process itself. To distinguish PjBL from ordinary project-based assignments, (Thomas, 2000) proposed five criteria that must be met for a learning activity to be categorized as PjBL: (1) centrality, where the project serves as the core of the curriculum rather than a mere supplement; (2) driving question, where the project focuses on a question or problem that compels students to engage with and understand the core concepts and principles of a discipline; (3) constructive investigations, where the project involves students in an investigative process that builds new knowledge; (4) autonomy, where the project is significantly driven by the students themselves; and (5) realism, where the project is linked to real-world contexts and issues beyond the classroom environment.

Hypothesis Development

Entrepreneurial Support Clarity and Digital Transformation Readiness Competency

In addition to contributing to the learning process, ESC influences individual readiness for digital transformation. In a psychometric study of the organizational readiness scale for digital innovations, Taganoviq et al. (2024) found that clarity of direction and institutional support are key antecedents shaping both individuals' and organizations' readiness to adapt to digital change. When a program's objectives, criteria, and guidelines are communicated transparently, participants gain a stronger cognitive foundation for understanding the direction of the digital transformation expected of them (Park & Kim, 2025; Touijer et al., 2026), thereby directly enhancing their

readiness, independent of the learning process itself. Based on this rationale, the following hypothesis is formulated:
H1: Entrepreneurial Support Clarity has a positive significant effect on Digital Transformation Readiness Competency.

Digital Entrepreneurship Capability dan Digital Transformation Readiness Competency

Individual digital entrepreneurship capability has been proven, both theoretically and empirically, to be a direct determinant of digital transformation readiness. Digital entrepreneurship is the utilization of digital technologies within entrepreneurial processes and ventures, requiring individuals to possess digital capabilities as a prerequisite for participation in the digital ecosystem (Nambisan et al., 2017, 2019). Wang et al. (2025), focusing on digital capability, organizational agility, and top management support, found that dimensions of digital capability (specifically digital perception, digital operation, and digital integration capability) contribute significantly to the readiness of both organizations and individuals to undertake digital transformation. Thus, the higher an individual's digital entrepreneurship capability, the greater their readiness to navigate the digital transformation process (Li et al., 2021). The following hypothesis is formulated:
H2: Digital entrepreneurship capability has a positive and significant effect on digital transformation readiness competency.

Entrepreneurial Support Clarity and Project-Based Learning

Entrepreneurial Support Clarity (ESC), encompassing objectives, instructions, and implementation guidelines, is a crucial prerequisite for the successful implementation of project-based learning methods. Arbaugh (2007) demonstrated that the "design and organization" dimension of teaching presence significantly contributes to the quality of the learner's experience, as unclear program directions tend to hinder active participation in learning activities. In the context of entrepreneurship, Botezat et al. (2025) and Sun and Xiong (2025) emphasized that institutional support does not automatically benefit recipients unless it is communicated clearly and remains accessible; this principle applies equally to the implementation of learning projects, where the initial clarity of objectives and criteria forms the foundation for participant engagement in the PjBL process. Based on this rationale, the following hypothesis is formulated:H3: Entrepreneurial Support Clarity has a positive significant effect on Project-Based Learning.

Digital Entrepreneurship Capability dan Project-Based Learning

Digital Entrepreneurship Capability encompasses technical mastery of digital technologies, human capital, and an opportunity-oriented mindset (Adekunle, 2026). Individuals with high digital entrepreneurship capabilities tend to be better equipped to optimally leverage the momentum of project-based learning, as they already possess the foundational digital skills and exploratory mindset required for active project engagement. In a systematic review of the drivers and success factors of digital entrepreneurship, Berman et al. (2024) identified active learning approaches, such as project-based learning, as relevant training strategies for developing Digital Entrepreneurship Capability (Okonkwo et al., 2026). It indicates a reciprocal relationship between an individual's existing capabilities and the effectiveness of their engagement in project-based learning. Based on this rationale, the following hypothesis is formulated:
H4: Digital Entrepreneurship Capability has a positive significant effect on Project-Based Learning.

Project-Based Learning dan Digital Transformation Readiness Competency

Empirical studies indicate that engagement in Project-Based Learning contributes significantly to students' Digital Transformation Readiness. Implementing project-based learning

effectively helps learners enhance their digital competencies by using technology to acquire, organize, store, present, and communicate information (Sutrisno et al., 2025). Project-Based Learning was found to have a strong, significant influence on digital pedagogical readiness (Hariyono et al., 2026). Similarly, research on the impact of the PjBL environment on digital literacy in higher education found a large effect size for learners' operational, information-navigational, social, creative, and critical skills (Miliou & Angeli, 2023; Otto et al., 2024). These findings consistently demonstrate that PjBL is not merely a learning method but also a crucial mechanism for shaping participants' digital readiness. The following hypothesis is formulated:
H5: Project-Based Learning has a positive significant effect on Digital Transformation Readiness Competency.

Based on the hypotheses formulated, the proposed research model illustrating the direct and mediating relationships among the variables is presented in Figure 1.

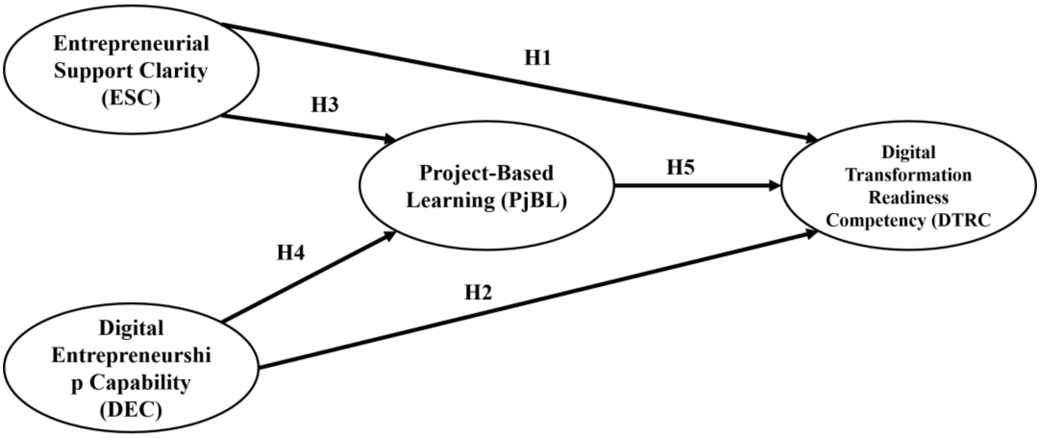

Figure 1. Proposed Empirical Model

RESEARCH METHOD

Research Design

This study employs a quantitative research design, combining a quasi-experimental method with survey-based data collection to test the proposed model (Cook et al., 1979; Hair, Black, et al., 2014). In this study, a Project-Based Learning intervention was first implemented as the treatment, after which participants' perceptions of the process were measured via a questionnaire to construct a structural model (SEM). This approach was selected because the research aimed not only to statistically test relationships between variables but also to evaluate and improve instructional practices cyclically, drawing upon Experiential Learning Theory (Kolb, 1984; Kolb et al., 2014).

Participant

The study participants were students at a vocational higher education institution who had completed a five-week course on Digital Transformation and Technopreneurship. This course was selected for its relevance to assessing digital transformation readiness for cultivating future entrepreneurs. The vocational education context was chosen because the curriculum structurally emphasizes industry-based practical learning, making it a relevant setting to test the effectiveness of a project-based entrepreneurship intervention involving direct industry partnerships. This characteristic aligns with the orientation of vocational education, which prioritizes the mastery of applied competencies and workforce readiness as key learning outcomes. Data collection was conducted longitudinally from March 5 to April 18, 2026, across four classes, comprising a total of

120 students. Given the limited number of sampling units, a saturated sampling technique was deemed the most appropriate approach (Sekaran & Bougie, 2016). During data collection for causality testing, questionnaires were distributed to the population, yielding a response rate of 75.83%. The remaining 29 students (24.17%) did not submit their responses, so only 91 eligible participants for the subsequent testing phase. The number of samples was considered sufficient based on the minimum sample size (Hair, Babin, et al., 2014).

In addition to students, this study involved 29 Micro, Small, and Medium Enterprises (MSMEs) in the Semarang area and its surroundings, serving as a collaborative platform for implementing Project-Based Learning. Semarang area was selected for its proximity to the campus, ensuring the program would benefit the community immediately surrounding the educational institution. MSME partners were selected purposively based on the following criteria: possessing a physical (offline) business location, lacking adequate business legal documentation (such as NIB, P-IRT, BPOM, or Halal certification), and offering at least three types of products; this selection ensured the partners were representative of the MSME profile most in need of support for digital transformation. Before implementation, all students and MSME partners were briefed on the research objectives and provided informed consent regarding the use of learning data and activity documentation for academic purposes, with guarantees ensuring the confidentiality of sensitive business data.

Research Instrument

Data were collected using several key instruments designed to measure learning processes and outcomes: (1) the Semester Learning Plan, integrated with the PjBL method and validated by the teaching team; (2) PjBL learning materials, such as job sheets and the Digital Readiness Assessment (DRA) instrument, developed based on the COBIT SME Focus Area concept to measure the digital readiness level of MSMEs (Rashikha et al., 2024); and (3) an output-based assessment rubric used consistently to evaluate student performance across aspects of conceptual understanding, quality of analysis, strategy implementation, and communication skills, thereby allowing for the comparison of achievements between stages on a standardized assessment scale (Table 1).

Table 1. Assessment Criteria

Score Range	Letter Grade
85,00 – 100	A
77,50 – 84,99	AB
70,00 – 77,49	B
62,50 – 69,99	BC
55,00 – 62,49	C
40,00 – 54,99	D
0 – 39,99	E

(4) A perception questionnaire using a 10-point Likert scale, completed by all 91 students at each stage, was used to measure students' level of understanding regarding the theoretical material and the effectiveness of the PjBL learning process. Student perceptions were used to examine the causal relationships among the model's variables. The Entrepreneurial Support Clarity variable was constructed from six indicators (Arbaugh, 2007), the Digital Entrepreneurship Capability variable with five indicators (Adekunle, 2026; Nambisan et al., 2017), Project-Based Learning variable with eight indicators (Berman et al., 2024; Yarmi et al., 2026), and the Digital Transformation Readiness Competency variable with five indicators (Krstić et al., 2026; Nambisan

et al., 2019).

Intervention Procedure

The research procedure follows the stages of the PjBL implementation cycle, designed in accordance with the four stages of Experiential Learning Theory (Kolb, 1984; Kolb et al., 2014), as follows:

1. Conceptual Reinforcement Stage regarding Digital Transformation
   Before entering the experiential learning cycle, participants receive conceptual reinforcement on digital transformation and technopreneurship through face-to-face lectures. Topics include the fundamental concepts of digital transformation, the MSME Digital Readiness Framework (COBIT SME Focus Area), and the basic principles of the Business Model Canvas. This stage aims to equip participants with a solid theoretical foundation before they engage directly in the field; it also serves as a cognitive prerequisite, ensuring that the reflection and conceptualization processes in subsequent ELT stages are meaningful. Participants' conceptual understanding at this stage is measured with a comprehension questionnaire to establish a baseline before the project intervention begins.
2. Concrete Experience (CE) Stage
   Students are placed directly in real-world situations with industry partners to experience authentic digital transformation challenges. During this stage, the 29 industry partners present the actual business challenges they face. Students are divided into 29 working groups to conduct field observations, define problems, create profiles, and perform digital readiness assessments for the MSME partners.
3. Reflective Observation (RO) Stage
   Students reflect on their field experiences with the guidance of lecturers. Group debriefing sessions are held to identify patterns, gaps, and root causes arising from concrete experiences, before moving on to the solution formulation stage.
4. Abstract Conceptualization (AC) Stage
   Based on their reflections, students formulate a conceptual framework for digital solutions, including business models, process flows, and technology solution prototypes, by drawing on the theories and digital transformation material covered in lectures. Lecturers guide students in connecting their field experiences with relevant theoretical concepts.
5. Active Experimentation (AE)
   Students implement the designed solution as a prototype or a concrete action plan, then present and test the results before industry partners. Feedback from industry partners at this stage serves as input for the subsequent learning cycle and simultaneously acts as the final project evaluation point.

This quasi-experimental design of intervention essentially comprises two stages: (1) the Conceptual Strengthening and Problem Formulation stage regarding digital transformation, and (2) the Project-Based Learning (PjBL) implementation stage, conducted in collaboration with MSME partners. The quantitative measurement structure follows a one-group pretest-posttest design, comparing student performance in Stage 1 (Conceptual Strengthening), the baseline condition, with that in Stage 2 (PjBL Implementation), the post-intervention condition, within the Digital Transformation and Technopreneurship course.

Data Analysis

Quantitative data analysis was conducted in two stages: (1) a descriptive-comparative analysis to compare the distribution of student grade categories between Stage 1 and Stage 2

(Creswell, 2009), and to analyze the achievement of Sub-Course Learning Outcomes relative to the weightings established in the Course Syllabus; and (2) Structural Equation Modeling (SEM) to test the causal relationships within the proposed model (Hair et al., 2014). As a supplement, qualitative data from student reflections and feedback from MSME partners were analyzed to enrich the study's findings (Creswell & Poth, 2016) and to identify patterns of obstacles, adaptation strategies, and lessons learned during implementation.

Validity and Reliability of the Instrument

The quality of the research data is ensured through two distinct avenues. Regarding content validity, all instructional materials, including the PjBL-integrated course syllabus, job sheets, and assessment rubrics, underwent an academic validation process (expert judgment) by the Study Program Coordinator and the teaching team to ensure alignment with Graduate Learning Outcomes (CPL) and institutional curriculum standards. Regarding measurement consistency, the DRA instrument, adapted from the COBIT SME Focus Area framework, ensures conceptual alignment of assessment dimensions across various partner profiles and is supported by recalibration procedures conducted by the teaching team. In the SEM analysis, the quality of the measurement instrument was verified through tests of convergent validity (outer loadings> 0.6; Average Variance Extracted > 0.5), discriminant validity (Fornell-Larcker criterion and cross-loadings), and reliability (Cronbach's Alpha and Composite Reliability > 0.7) (Fornell & Larcker, 1981; Hair, Babin, et al., 2014).

Bias Reduction and Objectivity

Bias in data collection and analysis was minimized through: (1) data triangulation, using multiple data sources to verify findings, including student achievement scores (quantitative), student perception questionnaires, and direct feedback from 29 MSME partners (qualitative); (2) output-based assessment, conducted objectively using physical evidence in the form of project artifacts to minimize subjective bias on the part of lecturers; and (3) peer review, involving discussions with the teaching team and mentors to ensure fair and impartial data interpretation (Podsakoff et al., 2003).

FINDINGS AND DISCUSSION

Participant Characteristics

Based on Table 2, the study participants were predominantly female (73 individuals, or 80.22%), while male participants numbered 18 (19.78%) out of a total of 91. This composition aligns with the gender imbalance patterns observed in business and management study programs across various higher education contexts, as documented by Wells et al. (2011), who noted that the proportion of women ranges from 33% to 75% depending on the business specialization and is consistent with findings regarding high female participation in vocational entrepreneurship education (Wang et al., 2025).

Table 2. Demographic Profile

Gender Characteristics	Number of Participants	Percentage (%)
Male	18	19.78
Female	73	80.22
Total	91	100

Conceptual Strengthening Regarding Digital Transformation

Before the intervention phase, students' understanding of the course syllabus, integrated with the PjBL method, was assessed (see Table 3). The results indicate that the majority of students (69%) reported being "Knowledgeable" of the presented syllabus, followed by 19% who reported being "Very Knowledgeable" of it. In comparison, only 12% reported being "Fairly Knowledgeable" of it. No students reported a lack of understanding, suggesting that the majority of participants generally understood the syllabus presentation well at the beginning of the course.

Table 3. Students' Understanding of the Course Syllabus

Understanding Category	Percentage (%)
Fairly Knowledgeable	12,00
Knowledgeable	69,00
Very Knowledgeable	19,00

At the conceptual reinforcement stage (see Table 4), student performance varied across the different aspects. The Digital Transformation Concepts aspect showed the best relative performance, with 21.40% of students achieving an A grade and 50.00% achieving an AB grade. Conversely, the MSME Model Analysis and Digital Readiness Assessment aspects showed lower performance; notably, no students achieved an A grade in MSME Model Analysis, and the majority (57.10%) fell into the B category for the Digital Readiness Assessment. This pattern indicates that, at the initial stage before gaining direct field experience, students' ability to apply more complex analytical frameworks remained limited relative to their fundamental conceptual understanding of digital transformation.

Table 4. Student Achievements in Theoretical Learning (Stage 1)

Achievement Aspect	A (%)	AB (%)	B (%)
Digital Transformation Concept	21,40	50,00	28,60
Analysis of MSME Models (BMC and VPC)	0,00	53,60	46,40
Digital Readiness Assessment	7,10	35,70	57,10

Student perceptions regarding the quality of material delivery and the guidance provided for the theoretical component reveal an identical pattern across both measured items. Specifically, 53.80% of students indicated they "Understood" that the digital transformation material was clearly presented and that comprehensive guidance was provided before the project's commencement; this was followed by 26.90% who reported "Fully Understood" and 19.20% in the "Moderately Understood" category. The consistency of results across these two items reinforces the validity of the findings: that the clarity of material delivery and initial guidance, collectively termed "Entrepreneurial Support Clarity", were perceived positively by the majority of students before they proceeded to the project implementation stage with MSME partners

Table 5. Students' Perceptions of Theory-Based Learning

Item Measurement	Fully Understand (%)	Understand (%)	Moderately Understand (%)
The material regarding digital transformation was presented clearly	26,90	53,80	19,20

Item Measurement	Fully Understand (%)	Understand (%)	Moderately Understand (%)
Comprehensive guidelines were provided before the course project began	26,90	53,80	19,20

Comparison of Achievements: Phase 1 (Conceptual Strengthening) and Phase 2 (PjBL Implementation)

Based on Table 6, there was a highly significant improvement in achievement between Stage 1 and Stage 2. In Stage 1 (Conceptual Strengthening and Problem Formulation regarding Digital Transformation), the majority of students fell into the AB (46.40%) and B (42.90%) grade categories, with only 10.70% achieving an A. In contrast, during Stage 2 (Implementation of Digital Transformation PjBL with MSMEs), 96.40% of students achieved an A, while the remaining 3.60% fell into the AB category, and no students were in the B category.

This pattern of sharp improvement indicates that student involvement in the Project-Based Learning intervention, conducted directly with MSME partners and encompassing the stages of Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation, contributed substantially to enhancing the quality of student learning outcomes compared to the conceptual strengthening provided solely through face-to-face lectures in Stage 1. These findings align with the principles of Experiential Learning Theory (Kolb et al., 2014), which asserts that the most meaningful learning occurs when conceptual knowledge is applied directly through concrete experience and active experimentation, rather than merely absorbed passively through theoretical exposure.

Table 6. Comparison of Stage 1 and Stage 2

Stage	A (%)	AB (%)	B (%)
Stage 1: Conceptual Strengthening and Problem Formulation for Digital Transformation	10,70	46,40	42,90
Stage 2: Implementation of Digital Transformation PjBL for MSMEs	96,40	3,60	0,00

Achievement of Sub-Course Learning Outcomes in PjBL Implementation

Table 7 illustrates the achievement of Sub-Course Learning Outcomes (CLO) during the PjBL implementation, revealing a pattern that consistently approaches the weights specified in the Semester Learning Plan (RPS), with achievement-to-weight ratios ranging from 77.20% to 86.90%. CLO 5 (Preparation of the MSME digitalization project report) recorded the highest achievement in both nominal terms (26.08% out of a 30.00% weight) and ratio (86.90%); this indicates that students performed most optimally in producing the final project output after completing the entire Experiential Learning cycle, aligning with its position as the culmination of the Active Experimentation stage in the fifth effective week.

Conversely, CLO 2 (Analysis of digital-based MSME business models) recorded the lowest achievement ratio (77.20%), followed by CLO 3 (Digital Readiness Assessment) at 77.50%. This pattern is consistent with the findings in Table 4, where aspects related to MSME Model Analysis (BMC and VPC) and Digital Readiness Assessment showed relatively lower academic achievement compared to the Digital Transformation Concept aspect during the conceptual reinforcement stage. The consistency of findings across these two tables indicates that students' analytical skills in applying structured frameworks (BMC, VPC, and DRA) are an area requiring further strengthening, particularly compared to their grasp of basic concepts or their ability to compile the final project output.

Overall, the total achievement of Sub-CLOs during the PjBL implementation reached 45.79% of the total 55.00% weight allocated for this component in the RPS, equivalent to an achievement ratio of 83.25%. This achievement demonstrates that the PjBL intervention generally met the established learning targets, although variations in outcomes across specific sub-learning outcomes (CLO) warrant attention when refining the instructional design for the next cycle, particularly for business model analysis and digital readiness assessment, which require more complex analytical skills.

Table 7. Achievement of Sub-Course Learning Outcomes

Sub-CLO	Description	Weight (%)	Achievement (%)	Ratio of Achievement to Weight (%)
CLO 1	Understand the concepts and urgency of digital transformation in organizations	5,00	3,95	79,00
CLO 2	Analyze digital-based business models for MSMEs	5,00	3,86	77,20
CLO 3	Digital Readiness Assessment (DRA)	10,00	7,75	77,50
CLO 4	Evaluate the impact of digitalization implementation	5,00	4,15	83,00
CLO 5	Prepare MSME digitalization project reports	30,00	26,08	86,90
Total		**55,00**	**45,79**	**83,25**

Obstacles and Solutions in the PjBL Implementation Process

Two primary obstacles were identified during implementation (Table 8). First, the varying levels of students' initial understanding of digital transformation concepts made it difficult for some to integrate these concepts with organizational strategic perspectives and digital business models; this was addressed through a phased conceptual strengthening approach combining blended learning, video-based learning, discussions, and case studies. Second, partner MSMEs did not share the same level of digital readiness, resulting in challenges such as limited technological understanding, time constraints, and resistance to change among some partners; this was addressed through a two-stage Digital Readiness Assessment (DRA) process, comprising an initial survey and an observation-based reassessment, alongside a persuasive approach and intensive communication to provide realistic recommendations tailored to each partner's capacity.

Evaluation of the PjBL Framework and Implementation Model

The implementation of Project-Based Learning (PjBL) in the Digital Transformation and Technopreneurship course demonstrates a strong correlation with Experiential Learning Theory (ELT). Students' knowledge is shaped not merely through the passive reception of information but through the transformation of concrete experiences gained through interaction with the business world. This success can be analyzed through the five criteria of PjBL (Thomas, 2000).

Centrality and Grasping Experience

PjBL is positioned as the central element of learning; projects involving assistance to MSMEs form the core of the curriculum, integrated directly into the course syllabus rather than serving as a mere supplement. It aligns with the "Abstract Conceptualization" stage of ELT, in which students grasp theoretical concepts (explicit knowledge) of business models and digital transformation, laying a foundation before engaging in fieldwork.

Driving Question as a Cognitive Trigger

Learning is driven by a guiding question regarding how to design effective digitalization strategies for partner MSMEs. It pushes students out of their comfort zone of simulations and into active learning, acting as a stimulus within the ELT cycle that facilitates the interpretation of theoretical information within the context of real-world problem-solving.

Constructive Investigations and Know-How Development

Students engage in constructive investigations through BMC analysis and COBIT-based DRA assessments with 29 MSME partners. It embodies the "Reflective Observation" stage of Experiential Learning Theory (ELT), allowing students to build know-how through hands-on practice and trial and error, insights unattainable from textbooks alone. The surge in students achieving an 'A' grade, rising from 10.70% in Stage 1 to 96.40% in Stage 2, provides descriptive evidence that constructive investigations effectively transform explicit knowledge into practical expertise.

Autonomy and Active Experimentation

The autonomy criterion grants student teams full independence to make strategic decisions for their partners. From an ELT perspective, this autonomy facilitates the "Active Experimentation" stage, where students act as "accommodators," learning through direct, hands-on experience. At the same time, lecturers shift their roles to become facilitators and mentors.

Realism as a Bridge for the Competence Gap

Realism is introduced through collaboration with actual partners, such as Dapur Barokah and Keripik Adinda. This connection to real-world contexts is crucial in ELT for bridging the gap between academia and the demands of the digital industry; by confronting genuine obstacles, such as technological resistance among MSME owners, students gain profound, subjective experiences that foster applied competence.

Overall, the integration of Project-Based Learning (PjBL) that meets these five criteria demonstrates that experiential learning enhances the effectiveness of entrepreneurship education. Students are not only cognitively prepared (job-ready) but also demonstrate readiness to run a business (business-ready) through field-tested experiences in digital transformation. Based on the overall findings above, specifically the integration of an OBE-based curriculum, a PjBL cycle aligned with ELT, and a COBIT-based digital transformation instrument, an implementation model can be synthesized, as illustrated in Figure 2. This model depicts how the curriculum foundation encompasses the ELT-based PjBL learning cycle, yielding two interconnected primary outcomes: student competencies that are both job-ready and business-ready, and the accelerated digital maturity of partner MSMEs, with reflection and reassessment mechanisms serving as feedback bridges for continuous curriculum calibration.

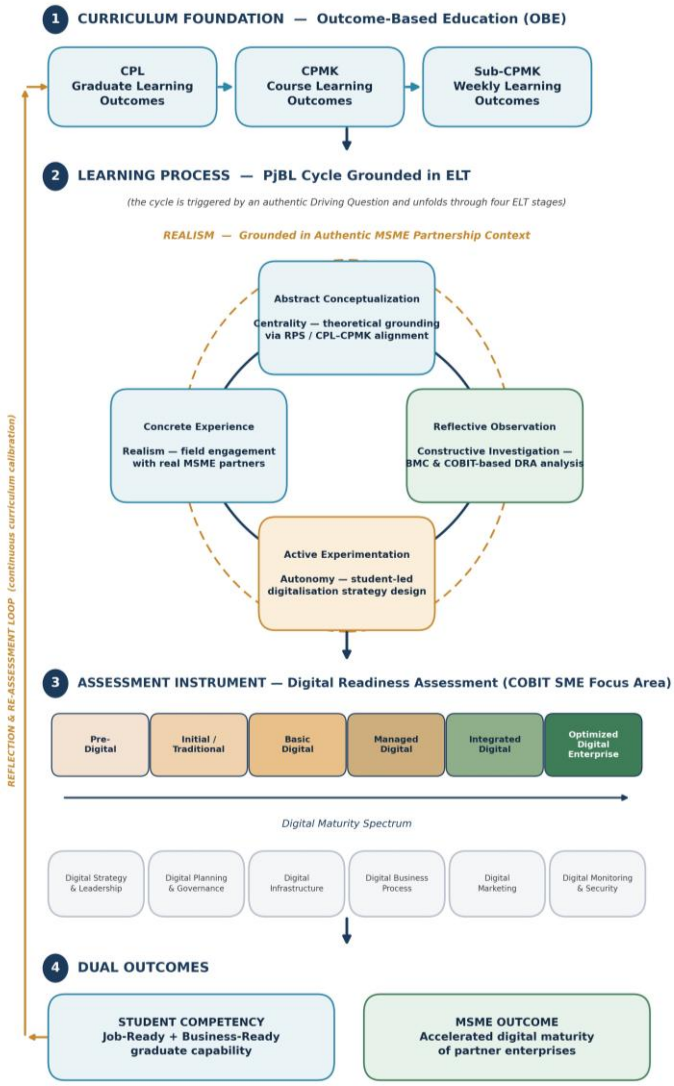

Figure 2. Implementation Model: Integrating Project-Based Learning and Outcome-Based Education to Accelerate the Digital Transformation of MSMEs

Measurement Model Evaluation Results

The measurement model evaluation assessed the convergent validity, discriminant validity, and reliability of four research constructs: Entrepreneurial Support Clarity (ESC), Digital Entrepreneurship Capability (DEC), Project-Based Learning (PjBL), and Digital Transformation Readiness Competency (DTRC). The SmartPLS test results are presented in Table 8.

Table 8. Validity and Reliability Test Results

Variable	Item	Outer Loading	AVE	Cronbach's Alpha	Composite Reliability
ESC	ESC1–ESC6	0,740–0,877	666	899	923
DEC	DEC1–DEC5	0,765–0,919	724	904	929
PjBL	PjBL1–PjBL8	0,603–0,842	595	900	921
DTRC	DTRC1–DTRC5	0,761–0,928	736	908	933

Based on Table 9, nearly all items across the four constructs exhibit outer loadings above 0.60, thereby meeting the convergent validity criteria (Hair, 2011). The sole exception is item PMK4 within the Project-Based Learning (PjBL) construct, which has a loading of 0.603. According to Hair, Black et al. (2014), items with loadings in the 0.40–0.70 range do not necessarily require removal, provided that their exclusion does not significantly increase the Average Variance Extracted (AVE) or Composite Reliability (CR). Since the AVE for the PjBL construct remained above the 0.50 threshold (0.595) despite retaining item PMK4, the decision was made to retain the item in the model to preserve the construct's content validity.

The AVE values for the four constructs range from 0.595 to 0.736, all exceeding the minimum threshold of 0.5, indicating that each construct explains more than half of the variance in its indicators and that the model satisfies convergent validity overall. Regarding reliability, Cronbach's Alpha values range from 0.899 to 0.908, and Composite Reliability values range from 0.921 to 0.933. Both metrics well exceed the 0.70 threshold and approach the "excellent" range; thus, it can be concluded that all measurement instruments in this study are consistent and reliable in measuring their respective constructs (Hair, Black, et al., 2014).

Discriminant Validity (Fornell-Larcker Criterion)

The diagonal values in Table 9 represent the square root of the AVE for each construct, while the off-diagonal values represent the correlations between constructs. The Fornell-Larcker criterion requires that a construct's square root of the AVE value be greater than its correlation with other constructs. The test results indicate that this criterion is met for the DEC, DTRC, and ESC constructs, as the square roots of their AVEs (0.851, 0.858, and 0.816) are higher than their correlations with other constructs (Fornell & Larcker, 1981).

Table 9. Fornell-Larcker Matrix

Construct	DEC	DTRC	ESC	PjBL
Digital Entrepreneurship Capability (DEC)	0,851			
Digital Transformation Readiness Competency (DTRC)	0,802	0,858		
Entrepreneurial Support Clarity (ESC)	0,709	0,661	0,816	
Project-Based Learning (PjBL)	0,752	0,777	0,795	0,771

However, a slight anomaly was observed regarding the PjBL construct: the square root of the AVE value for PjBL (0.771) was marginally lower than its correlations with DTRC (0.777) and ESC (0.795). This situation suggests a potential conceptual overlap between PjBL and the other two constructs, which is understandable, given that the project-based learning (PjBL) process is theoretically designed to bridge entrepreneurial support (ESC) and digital transformation readiness competency (DTRC), resulting in a relatively high degree of shared conceptual variance among the three. To more robustly verify discriminant validity, the results were further confirmed using the Heterotrait-Monotrait Ratio (HTMT) criterion (Hair, Black, et al., 2014). The HTMT results indicated that all construct pairs exhibited ratios below 0.90 (DEC-DTRC = 0.877; DEC-ESC = 0.786; DTRC-ESC = 0.730; DEC-PjBL = 0.830; DTRC-PjBL = 0.863; ESC-PjBL = 0.878). Thus, in accordance with the recommended criteria, the overall discriminant validity between constructs remains acceptable; however, the HTMT values for ESC-PjBL and DEC-DTRC, which approach 0.88, warrant close attention in future research regarding instrument development.

Hypothesis Testing

Once the measurement model is confirmed as valid and reliable, the next stage is to test the structural model (inner model) to assess the causal relationships among constructs. Hypothesis testing is conducted using a resampling-based bootstrap procedure, yielding path coefficients (β), t-statistics, and p-values, as presented in Table 10.

Table 10. Hypothesis Testing Results

Hypothesis	Path	Path Coefficient (β)	t-statistic	p-value	Note
H1	ESC → DTRC	-0,035	0,317	0,751	Rejected
H2	DEC → DTRC	0,509	4,125	0,000	Accepted
H3	ESC → PjBL	0,525	4,825	0,000	Accepted
H4	DEC → PjBL	0,380	3,195	0,001	Accepted
H5	PjBL → DTRC	0,422	2,965	0,003	Accepted

Using thresholds of t-statistic > 1.96 and p-value < 0.05 (5% significance level), the test results indicate that four of the five research hypotheses (H2, H3, H4, and H5) are supported by the data. In contrast, one hypothesis (H1) is rejected. The path with the strongest influence is ESC → PjBL (β = 0.525), followed by DEC → DTRC (β = 0.509), PjBL → DTRC (β = 0.422), and DEC → PjBL (β = 0.380). Conversely, the ESC → DTRC path shows a very small, and even negative, coefficient (β = -0.035; p = 0.751), which is statistically indistinguishable from zero (Hair, Black, et al., 2014).

Mediation Analysis

Table 11 presents the results of the indirect effect analysis conducted to confirm the mediating role of PjBL in this research model. Bootstrapping results indicate that the total effect of ESC on DTRC via PjBL is 0.221 and statistically significant (p = 0.034), while the total effect of DEC on DTRC via PjBL is 0.162 and also statistically significant (p = 0.015). Since both p-values fall below the 0.05 threshold (Hair et al., 2017), these findings confirm that PjBL significantly mediates the relationships of ESC and DEC with DTRC.

Table 11. Indirect Effect Result

	P Values	Total Effect
ESC → PjBL → DTRC	0.034	0.221
DEC → PjBL → DTRC	0.015	0.162

R^2 Value

The R-square (R^2) value indicates the proportion of the variance in the endogenous variable that is explained by its exogenous variables. The test results are presented in Table 12.

Table 12. R Square Value

Endogenous Variable	R Square	R Square Adjusted
Digital Transformation Readiness Competency (DTRC)	0,713	0,703
Project-Based Learning (PjBL)	0,703	0,696

R^2 values of ≥ 0.67 are categorized as strong/substantial, 0.33–0.67 as moderate, and 0.19–0.33 as weak. The R^2 value of 0.713 for DTRC indicates that ESC, DEC, and PjBL together explain

71.3% of the variation in Digital Transformation Readiness Competency, while variables outside the model account for the remaining 28.7%. Similarly, the R^2 value of 0.703 for PjBL indicates that ESC and DEC simultaneously explain 70.3% of the variation in Project-Based Learning. Both R^2 values fall into the strong/substantial category; thus, the structural model developed in this study has high explanatory power for both endogenous variables (Hair, Black, et al., 2014).

To complement the model fit evaluation, a Model Fit Summary from SmartPLS is also presented, comparing the saturated model (without path constraints) with the estimated model (based on hypothesized structural paths), as shown in Table 13.

Table 13. Model Fit Summary

Indicator	Saturated Model	Estimated Model
SRMR	0,081	0,081
d_ULS	1,984	1,984
d_G	1,219	1,219
Chi-Square	553,417	553,417
NFI	0,733	0,733

The Standardized Root Mean Square Residual (SRMR) value of 0.081 is slightly above the recommended threshold of 0.08 (Hair et al., 2017). Yet, it remains within the acceptable fit range, as some researchers set a tolerance limit of up to 0.10 for PLS-SEM models. The d_ULS (1.984) and d_G (1.219) values represent measures of discrepancy between the empirical and model-implied correlation matrices; ideally, they are compared against critical values derived from bootstrapping to determine their significance. The Chi-Square value of 553.417 is considered high, but because it is highly sensitive to sample size, it is rarely used as the sole criterion in PLS-SEM. Meanwhile, the Normed Fit Index (NFI) of 0.733 falls below the ideal threshold of 0.90, indicating that the model's fit relative to the baseline is only moderate (Hair et al., 2017).

The Influence of Entrepreneurial Support Clarity on Digital Transformation Readiness Competency

The test results indicate that Entrepreneurial Support Clarity does not have a positive and significant direct effect on Digital Transformation Readiness Competency ($\beta = -0.035$; $t = 0.317$; $p = 0.751$); thus, H1 is rejected. This finding offers an interesting contrast to the arguments of Taganoviq et al. (2024), who emphasize the importance of institutional support as a pillar in building digital transformation readiness. The discrepancy between this study's findings and that proposition can be explained through a mediation perspective: clear entrepreneurial support does not automatically translate directly into digital readiness competence; rather, it requires an intervening process of active and applied learning, specifically, Project-Based Learning (PjBL). In other words, the clarity of support serves as an enabling condition that impacts digital transformation readiness only after being processed through project-based learning experiences, rather than acting as a direct determinant. The non-significance of H1 actually reinforces the relevance of PjBL as a mediating variable within the research model.

The Influence of Digital Entrepreneurship Capability on Digital Transformation Readiness Competency

The test results indicate that Digital Entrepreneurship Capability has a positive and significant effect on Digital Transformation Readiness Competency ($\beta = 0.509$; $t = 4.125$; $p = 0.000$); thus, H2 is accepted. These findings align with the concept of digital entrepreneurship proposed by Nambisan et al. (2017), which posits that digital capabilities are not merely supporting tools but have become central to the entrepreneurial process itself; consequently, individuals with strong digital capabilities are naturally better prepared to navigate technological and business model changes. These results are further reinforced by Adekunle (2026), whose findings show that digital competence serves as a significant predictor of digital transformation readiness at both individual and organizational levels. Overall, the findings regarding H2 confirm that strengthening digital entrepreneurship capability is one of the most effective and direct pathways to building digital transformation readiness, without the need for intervening learning processes or other mediators.

The Influence of Entrepreneurial Support Clarity on Project-Based Learning

Test results indicate that Entrepreneurial Support Clarity has a positive and significant effect on Project-Based Learning (β = 0.525; t = 4.825; p = 0.000); thus, H3 is accepted. These findings suggest that the clearer and more structured the entrepreneurial support students receive, whether in the form of mentoring, access to resources, or clarity about the program's direction, the more optimal their engagement and effectiveness in the project-based learning process. Notably, among the five paths tested, the ESC → PjBL relationship was the strongest, underscoring that clarity of support is a crucial prerequisite for students to execute entrepreneurial projects effectively.

These findings align with the perspective of Arbaugh (2007), who emphasized that course structure and the clarity of support are vital determinants of student engagement and success in both project-based and online learning environments. When direction, expectations, and supporting resources are clearly communicated, students possess a stronger cognitive and motivational foundation for active engagement in complex projects. Consequently, this study reinforces the argument that clear institutional support is not merely an accessory but a structural prerequisite for the effectiveness of project-based learning within the context of digital entrepreneurship education.

The Influence of Digital Entrepreneurship Capability on Project-Based Learning

The test results indicate that Digital Entrepreneurship Capability has a positive and significant effect on Project-Based Learning (β = 0.380; t = 3.195; p = 0.001); thus, H4 is accepted. This implies that the higher the digital entrepreneurship capabilities possessed by learners, encompassing digital literacy, the ability to identify technology-based opportunities, and skills in utilizing digital platforms, the better the quality of their engagement and learning outcomes in entrepreneurial projects.

These findings align with the perspective of Berman et al. (2024), who assert that digital capabilities serve as a strategic resource enabling both individuals and organizations to execute entrepreneurial initiatives in a more adaptive and evidence-based (data-driven) manner. In an educational context, learners possessing adequate digital entrepreneurship capabilities are better equipped to translate project tasks into tangible solutions relevant to digital market demands, thereby rendering the PjBL process more meaningful and applicable. The results also suggest a mutually reinforcing relationship between the learners' pre-existing capabilities and the effectiveness of the implemented project-based learning method; PjBL not only fosters new capabilities but also relies on an initial foundation of capabilities to function optimally.

The Influence of Project-Based Learning on Digital Transformation Readiness Competency

The test results indicate that Project-Based Learning has a positive and significant effect on Digital Transformation Readiness Competency (β = 0.422; t = 2.965; p = 0.003); thus, H5 is accepted. This finding represents one of the study's most significant outcomes, as it directly supports the primary claim that the project-based learning (PjBL) intervention is effective in fostering learners' digital transformation readiness competence.

Interestingly, this pathway becomes particularly meaningful when viewed alongside the non-significant result of H1. As previously discussed, explicit entrepreneurial support (ESC) does not directly shape digital transformation readiness; instead, it exerts a strong influence on PjBL (H1), which in turn significantly impacts DTRC (H5). This pattern indicates that Project-Based Learning acts as a mediating mechanism, transforming conditional entrepreneurial support into applied, measurable digital readiness competence. In other words, learners do not achieve readiness for digital transformation simply by receiving explicit support, but rather because that support is processed through active learning experiences involving real-world projects. This finding reinforces the pedagogical premise that PjBL is not merely a teaching method but a transformative mechanism bridging institutional resources (support, capabilities) with individual competencies ready for the digital era, a key theoretical contribution of this study to the literature on digital entrepreneurship education.

CONCLUSIONS

This study aims to develop a Project-Based Learning (PjBL) model grounded in the Outcome-Based Education (OBE) curriculum to enhance the effectiveness of entrepreneurship courses. It also examines the influence of Entrepreneurial Support Clarity (ESC) and Digital Entrepreneurship Capability (DEC) on Digital Transformation Readiness Competency (DTRC), with Project-Based Learning (PjBL) serving as a mediating variable. The results indicate that ESC significantly influences PjBL but has no direct effect on DTRC; conversely, DEC significantly impacts both PjBL and DTRC. PjBL is shown to have a significant effect on DTRC and acts as a full mediator in the ESC-DTRC relationship. These findings confirm that the developed PjBL model, following the Experiential Learning Theory cycle and aligned with the CLO mapping within the OBE framework, effectively boosts student learning outcomes and fosters digital transformation readiness among MSME partners (increasing the proportion of partners achieving an 'A' rating from 10.70% to 96.40%). However, ongoing mentorship remains necessary, given that most partners currently operate at a 'Basic Digital' level. This suggests that PjBL-based student mentorship can measurably improve MSME digital readiness, even if full digital maturity has not yet been reached.

Theoretically, this study contributes to the body of knowledge on entrepreneurship education by offering an integrative model that bridges the gap between the largely conceptual literature on digital entrepreneurship education and the need for empirically tested, OBE-aligned practical curriculum models implemented in real classrooms and with actual MSME partners. The finding that PjBL fully mediates the ESC-DTRC relationship enriches the understanding of entrepreneurial support system models; it demonstrates that the gap between available support (the support system) and its impact on individual readiness can only be bridged through real-world practical experience, contributing to the understanding of the "support-to-readiness gap" within entrepreneurship literature. In practical terms, the resulting model can serve as a reference for other vocational study programs when designing entrepreneurship courses that simultaneously meet OBE-based learning outcomes and contribute to achieving Key Performance Indicator 7 (IKU 7) regarding the SDGs, specifically through partnerships with MSMEs acting as both learning partners and beneficiaries.

LIMITATION & FURTHER RESEARCH

This study has several methodological limitations that must be transparently acknowledged. First, the relatively short duration of the PjBL implementation (five effective weeks) limited the measurable depth of the digital transformation's impact on the MSME partners, given that organizational-level digital changes typically occur gradually and continuously. Fourth, the

Digital Readiness Assessment instrument was evaluated directly by students without formal statistical reliability testing (such as Cronbach's alpha); consequently, measurement consistency across assessment groups relied on recalibration procedures conducted by the teaching team rather than on standardized psychometric evidence. Based on these limitations, several directions for future research are recommended. Future studies should conduct formal reliability testing on the Digital Readiness Assessment instrument and incorporate longitudinal studies to assess the sustainability of the partner MSMEs' digital transformation after the student mentorship period concludes, especially since the digital maturity level achieved in this study reached only Level 2 (Basic Digital) and could potentially regress without ongoing support. Finally, future research could explore the relationship between this integrative OBE-PjBL model and other institutional performance indicators, such as the rate of young entrepreneurs among graduates—to strengthen the contribution of entrepreneurship education toward narrowing the national entrepreneurship ratio gap.

ACKNOWLEDGEMENT

During the drafting process, the author utilized a large language model to a limited extent during the brainstorming stage. The author has ensured the accuracy of the content, its consistency with actual data, and adherence to standards of academic integrity. The use of AI in this research does not replace the author's role as the primary party responsible for the originality, validity, and scientific contribution of this manuscript.

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APPENDIX

Variable	Code	Item Measurement (10-Likert Scale)
Entrepreneurial Support Clarity (ESC) (Arbaugh, 2007)	ESC1	The objectives of the course project were clearly communicated at the start of the course.
	ESC2	Instructions for the course project were easy to understand.
	ESC3	Comprehensive project guidelines were provided before the course project began.
	ESC4	Material related to digital transformation was clearly presented by the lecturer.
	ESC5	Assessment criteria for the course project were explained transparently.
	ESC6	The timeline for the course project was structured and clearly communicated.
Digital Entrepreneurship Capability (DEC) (Adekunle, 2026; Nambisan et al., 2017)	Dec1	Overall, the course project provided a meaningful digital entrepreneurship learning experience.
	Dec2	Technology and digital tools were used effectively during the course project.
	Dec3	I gained hands-on experience using new digital tools during the course project.
	Dec4	Digital technology was used to support the completion of the course project.
Project-Based Learning (PjBL) (Berman et al., 2024; Yarmi et al., 2026)	PjBL1	The course project is relevant to real-world issues in the business or industrial sector.
	PjBL2	The course project activities help me understand the core concepts of the course material.
	PjBL3	I have the opportunity to contribute actively to the project team.
	PjBL4	The lecturer provides adequate guidance during the execution of the course project.
	PjBL5	I receive constructive feedback from the lecturer on my work.
	PjBL6	The evaluation of the course project is conducted objectively and based on outcomes.
	PjBL7	I am given the opportunity to reflect on the project process and results.
	PjBL8	I understand my strengths and weaknesses after completing the course project.

Digital Transformation Readiness Competency (DTRC) (Krstić et al., 2026; Nambisan et al., 2019)	DTRC1	I am able to apply problem-solving skills effectively in the course project.
	DTRC2	I am able to work effectively in a team during the course project.
	DTRC3	I am able to communicate effectively during the course project.
	DTRC4	I am able to think critically in completing the course project.
	DTRC5	I am able to generate creative ideas in solving problems within the course project.