

Direct-Action Paradox in Higher Education: How Artificial Intelligence Bypasses Traditional Psychological Mediators in Developing Technopreneurship Competency

Megha Sakova^{1*}, Rd. Ghina Fithriyah², Farhan Mukti Mutakin³, Muhammad Zaidan Ilham Supriadi⁴, Risnawati Aisy⁵

¹⁻⁵Management Study Program, Faculty of Economics and Business, Universitas Muhammadiyah Bandung

*Email: meghasakova@umbandung.ac.id

Abstract

The rapid integration of generative technologies in the Global South necessitates a reassessment of how higher education institutions foster graduate readiness for the digital economy. This study examines the structural synergy between the utilization of Artificial Intelligence (AI) and e-learning ecosystems in developing technopreneurship competency among management students in Indonesia. Using a multi-path structural equation modeling (SEM-PLS) approach, data were collected from 168 senior-level undergraduate students to test 12 hypotheses encompassing technological, cognitive, and contextual factors. The results reveal that AI utilization serves as the undisputed primary engine for competency acquisition, exerting a transformative influence that far outweighs traditional e-learning infrastructure. A distinctive "Direct-Action Paradox" was identified, in which AI directly drives competency, bypassing traditional psychological mediators such as digital self-efficacy and formalized intention. This finding suggests that the immediate utility and accessibility of generative AI may redistribute aspects of cognitive agency from individuals to intelligent technological systems, enabling competency development through direct task execution rather than sequential psychological processes. Conversely, e-learning systems were found to be effective primarily as structural facilitators that sharpen entrepreneurial alertness. Furthermore, Importance-Performance Map Analysis (IPMA) identifies AI performance as a high-priority area for institutional reform, suggesting a strategic pivot from maintaining basic digital platforms toward deep-tier AI integration. However, the findings also highlight the importance of balancing AI adoption with critical and reflective learning practices to mitigate the risk of excessive technological dependency. These findings provide a robust framework for university administrators seeking to balance global technological trends with local ethical grounding in the pursuit of resilient technopreneurial graduates.

Keywords: Artificial Intelligence; E-Learning Ecosystems; Technopreneurship Competency; Entrepreneurial Alertness; Higher Education; Generative AI

A. INTRODUCTION

The ongoing digital transformation within Indonesia's higher education sector necessitates a fundamental re-evaluation of how graduates are prepared for an increasingly technology-driven labor market. While academic excellence remains a cornerstone of university education, the contemporary economic environment demands graduates with adaptive and innovative competencies in technopreneurship (Utama et al., 2026). In this study, technopreneurship competency refers to the integrated capability to identify, develop, and implement technology-driven business opportunities through the combination of entrepreneurial judgment, digital proficiency, and innovation-oriented problem solving. This transition is particularly critical in the Global South, where the intersection of artificial intelligence (AI), entrepreneurship education, and curriculum transformation is reshaping how innovation is taught and practiced (Khoza, 2026).

Central to this evolution is the utilization of Artificial Intelligence and advanced e-learning systems, which have become pivotal factors in supporting competency development (Abdelmagid et al., 2025). However, empirical observations across Indonesian universities suggest a persistent disconnect between access to technology and its optimal application for venture creation. Many students primarily utilize generative AI tools, such as ChatGPT, for fundamental academic tasks rather than for strategic market analysis or digital business modeling (Mwaanga et al., 2026). This gap underscores the importance of human-computer interaction theories, in which the alignment between human cognitive capacity and technological support—often referred to as digital trust—determines the feasibility and desirability of entrepreneurial aspirations (Duong, 2025). More importantly, the emergence of generative AI raises a new theoretical question regarding whether competency development

* Corresponding author

continues to depend primarily on traditional psychological mechanisms, such as self-efficacy and entrepreneurial intention, or whether intelligent technologies can directly facilitate competence acquisition by embedding analytical and creative capabilities within the technological system itself.

Moreover, the development of technopreneurship increasingly relies on domain-specific digital competencies, including fintech self-efficacy and AI-related skills, which significantly influence entrepreneurial intentions (Wach et al., 2026). Despite a growing propensity toward sustainable and digital entrepreneurship, factors such as risk awareness and subjective norms continue to play complex roles in determining entrepreneurial alertness within higher education (Akçaba et al., 2026). Given these dynamics, there is an urgent need to optimize technology-based learning strategies to ensure that the integration of AI and e-learning systems effectively enhances student readiness for technology-based entrepreneurship challenges.

Consequently, this study aims to analyze the influence of utilizing Artificial Intelligence and e-learning systems on the development of technopreneurship competencies among management students in Indonesia. By investigating these variables simultaneously, the research seeks to fill a gap in the current literature on how emerging technological tools can be harmonized with pedagogical frameworks to foster a resilient and competitive technopreneurial spirit. Furthermore, this study contributes to the growing literature on AI-enabled learning by examining whether AI's influence on technopreneurship competency follows conventional psychological pathways or operates through a more direct mechanism of competency development within digitally augmented learning environments.

B. LITERATURE REVIEW

The Integration of TPB and Human Capital Theory

The theoretical architecture of this study is anchored in the convergence of the Theory of Planned Behavior (TPB) and Human Capital Theory, providing a comprehensive lens to examine how technological tools evolve into technopreneurial outcomes. Traditionally, the TPB posits that three types of considerations guide human behavior: attitudes toward the behavior, subjective norms, and perceived behavioral control (Ajzen, 1991). In the contemporary landscape of Indonesian higher education, perceived behavioral control is increasingly synonymous with digital self-efficacy and the ability to master emerging technologies such as artificial intelligence (Wach et al., 2026). This cognitive evaluation of an individual's capability is far from static; rather, it is significantly bolstered by the accessibility of generative AI tools, which enhance the perceived feasibility of complex business ventures (Mwaanga et al., 2026). Furthermore, technological competencies act as domain-specific constructs that extend the explanatory power of the TPB framework, where specific knowledge of AI and self-confidence in utilizing these tools directly influence the intention to pursue innovation-driven entrepreneurship (Ha et al., 2025).

Complementing this psychological perspective, Human Capital Theory provides a structural justification for integrating digital tools into the academic curriculum. It suggests that individuals who invest in specific skill sets, such as AI-related digital competencies, gain a substantial competitive advantage and increased productivity (Núñez-Canal et al., 2026). In the rapidly shifting economic landscape of the Global South, these competencies are no longer optional but represent a strategic form of human capital necessary for navigating curriculum transformation and institutional digital transformation (Khoza, 2026). The synergy between these two theories suggests that while higher education provides the structural investment in human capital through AI and e-learning systems, the actual transition into technopreneurship is dictated by the alignment of human cognitive capacity with technological support (Duong, 2025). The effectiveness of this investment relies heavily on the faculty's ability to foster learning environments where technology is perceived not merely as a tool, but as a strategic ally in decision-making and risk management (Medina-Vidal et al., 2025). Thus, the proposed model posits that technological exposure transforms into tangible competency only when individuals possess the cognitive orientation and digital trust required to navigate complex business environments (Duong, 2025).

However, the emergence of generative AI introduces a potentially important extension to both TPB and Human Capital Theory. Unlike conventional digital technologies that primarily support human decision-making, generative AI increasingly embeds analytical, creative, and problem-solving capabilities within the technological artifact itself. As a result, competency development may not always depend on sequential psychological mechanisms such as self-efficacy formation and intention development. Instead, intelligent systems may serve as operant resources, partially redistributing cognitive agency between humans and technology, enabling individuals

to perform complex entrepreneurial tasks through direct interaction with AI-enabled platforms. This perspective suggests a direct pathway through which AI contributes to competency acquisition, complementing traditional TPB assumptions and extending the human capital perspective into the era of intelligent technologies.

Artificial Intelligence as a Cognitive Catalyst for Entrepreneurship

The integration of Artificial Intelligence (AI) within Indonesia's entrepreneurial landscape has evolved beyond rudimentary automation, emerging as a sophisticated strategic ally in complex decision-making processes (Sánchez Gonzales et al., 2026). As a cognitive catalyst, AI redefines venture dynamics by uncovering systematic patterns in behavioral data and providing robust frameworks for professional project conceptualization (Medina-Vidal et al., 2025). In the context of higher education, a student's propensity to adopt AI is no longer a peripheral technological curiosity but a central driver of entrepreneurial alertness and long-term economic resilience (Akçaba et al., 2026). Despite this potential, a critical bottleneck persists in many Indonesian institutions: students frequently prioritize generative platforms, such as ChatGPT, for their perceived ease of use in mundane academic assignments rather than exploiting their capacity for high-level business innovation and strategic market disruption (Mwaanga et al., 2026).

Furthermore, the potency of AI as an entrepreneurial engine is intrinsically linked to the acquisition of AI-related digital competencies and fintech-specific self-efficacy (Wach et al., 2026). Mastery of AI knowledge and a high degree of self-confidence in navigating specialized tools are potent predictors of sustainability-oriented entrepreneurial intentions (Ha et al., 2025). When undergraduates successfully synchronize their cognitive evaluations of opportunity attractiveness with advanced technological support, entrepreneurship is perceived as a more feasible and desirable vocational trajectory (Duong, 2025). However, recent developments in generative AI suggest its influence may extend beyond its conventional role as a supporting technology. Unlike traditional digital systems that require extensive user expertise before producing meaningful outcomes, generative AI can provide immediate access to analytical reasoning, content generation, opportunity exploration, and business ideation capabilities. Consequently, some entrepreneurial tasks that previously depended heavily on accumulated knowledge, self-confidence, and planning can now be partially performed through direct interaction with intelligent systems. This shift indicates that AI may function not only as a learning tool but also as a cognitive partner that augments human capability in real time.

From this perspective, the entrepreneurial value of AI lies not merely in enhancing self-efficacy but in reducing cognitive barriers associated with opportunity recognition, strategic analysis, and venture design. As intelligent systems increasingly participate in these activities, the process of competency acquisition may become less dependent on sequential psychological development and more reliant on human–AI collaboration. Such a perspective provides a theoretical basis for understanding why AI-driven competency formation may occur through direct mechanisms alongside, or even in place of, traditional psychological pathways. Consequently, the optimization of AI within curricula necessitates a radical shift from isolated technical instruction toward integrated educational models that harmonize technical proficiency with strategic value guidance (Jiang, 2026). Such a transformation positions AI as the intellectual core that empowers the next generation of professionals to shape and navigate the burgeoning green digital economy actively (Abdelmagid et al., 2025).

E-Learning Systems and the Digital Learning Ecosystem

E-learning systems within the Indonesian pedagogical infrastructure serve as more than mere repositories for digital content; they constitute the essential environmental scaffolding for fostering independent, innovative, and problem-oriented inquiry. In the current educational landscape, the proliferation of Learning Management Systems (LMS) and various video conferencing platforms facilitates a structured yet flexible delivery of knowledge, bridging geographical divides through real-time synchronous interaction. Despite this digital expansion, a persistent challenge remains in the tendency of these systems to prioritize theoretical saturation over practical modality, often failing to fully integrate business innovation or practice-based learning into the digital curriculum. For e-learning to transcend its role as a passive delivery mechanism, the design focus must shift from purely technical or content-centric architectures to those that prioritize user experience and high-quality interaction. Recent advancements in the field emphasize the transformative potential of immersive environments—such as the metaverse and FrameVR—when combined with generative AI tools to create high-fidelity educational experiences (Abdelmagid et al., 2025). These sophisticated ecosystems directly enhance student awareness of green digital concepts and cultivate specialized e-entrepreneurship skills by providing a sandbox for digital product creation (Abdelmagid et al., 2025). Furthermore, integrating locally grounded project-

based learning into these digital platforms enables deeper engagement with entrepreneurial role models and practical projects, effectively narrowing the gap between abstract understanding and tangible venturing (Adjimah et al., 2026).

Unlike generative AI, which increasingly functions as an active cognitive partner in entrepreneurial problem-solving, e-learning systems primarily operate as environmental and structural enablers of learning. Their contribution is often indirect, creating conditions that support opportunity recognition, collaborative exploration, and reflective knowledge construction rather than directly generating entrepreneurial competence. Consequently, the effectiveness of e-learning ecosystems may depend less on content delivery itself and more on their capacity to stimulate entrepreneurial alertness by exposing learners to emerging trends, market signals, and innovation opportunities. By fostering an environment that encourages self-directed learning and innovative problem-solving, e-learning systems provide the stability needed for technopreneurial competence to flourish in a rapidly evolving, digital-first economy. From this perspective, e-learning systems can be conceptualized as the analytical scaffolding for digital entrepreneurship education, supporting students' cognitive processes for identifying, evaluating, and responding to entrepreneurial opportunities.

Digital Self-Efficacy: The Psychological Bridge

Digital self-efficacy serves as a critical psychological conduit through which technological exposure is converted into entrepreneurial action. Rather than being a mere inventory of technical skills, it represents an individual's internal conviction in their ability to harness digital complexity for venture creation (Wach et al., 2026). Within the Indonesian higher education landscape, the sudden ubiquity of generative artificial intelligence has necessitated a more nuanced understanding of this psychological state. Students who possess high digital self-efficacy do not merely use technology; they perceive themselves as proficient masters of AI-related digital competencies, which in turn fosters a resilient Fintech entrepreneurial identity and stronger vocational intentions (Wach et al., 2026). The importance of this psychological bridge is further emphasized when analyzing the synergy between AI knowledge and personal confidence. Research suggests that undergraduates with a robust sense of AI self-efficacy are significantly more inclined toward sustainability-oriented entrepreneurship, viewing technological disruptions as manageable opportunities rather than insurmountable threats (Ha et al., 2025). This confidence is often nurtured by the perceived ease of use associated with generative tools, such as ChatGPT, which reinforces the belief that complex business tasks are achievable through digital collaboration (Mwaanga et al., 2026).

Nevertheless, the emergence of highly intuitive generative AI systems introduces an important theoretical consideration. Traditional self-efficacy theory assumes that individuals must first develop confidence in their abilities before successfully performing complex tasks. However, contemporary AI platforms increasingly provide embedded guidance, automated reasoning, and real-time problem-solving support, substantially reducing the expertise required for task execution. Consequently, individuals with varying levels of digital self-efficacy may achieve comparable outcomes when supported by advanced AI systems. This possibility does not diminish the theoretical importance of digital self-efficacy; rather, it suggests that its mediating role may become less pronounced in contexts where intelligent technologies actively compensate for limitations in user knowledge and confidence. As generative AI becomes more accessible and user-friendly, competency development may increasingly emerge from human–AI interaction rather than solely from internally developed perceptions of capability. Ultimately, the transition from a passive user to an active technopreneurial agent depends on this alignment of digital trust and perceived personal capability (Duong, 2025). At the same time, emerging AI-enabled learning environments raise the possibility that entrepreneurial competency can, under certain conditions, be developed through direct technological engagement even when traditional psychological mechanisms remain underdeveloped. Without a stable foundation of digital self-efficacy, even the most advanced AI and e-learning ecosystems may fail to trigger the innovative behavior necessary for Indonesia's future economic resilience.

Entrepreneurial Alertness in the Age of Generative AI

Entrepreneurial alertness, traditionally conceptualized as the cognitive capacity to identify opportunities that others overlook, has undergone a radical transformation in the wake of the Fourth Industrial Revolution. In the current Indonesian landscape, this alertness is increasingly driven by an individual's propensity toward artificial intelligence and their awareness of the digital risks inherent in a volatile market (Akçaba et al., 2026). As generative AI platforms—ranging from large language models to AI-driven content creation tools—become ubiquitous, they provide students with unprecedented opportunities to develop sound problem-solving and

critical-thinking dexterity (Rahal et al., 2026). These tools do not merely assist in task completion; they act as strategic allies that redefine the dynamics of entrepreneurship by enhancing decision-making capabilities and allowing for the rapid identification of market gaps (Sánchez Gonzales et al., 2026).

The emergence of generative AI has fundamentally altered the innovative behavior of aspiring technopreneurs, offering both a sandbox for experimentation and a catalyst for systemic innovation (Rahal et al., 2026). By leveraging AI to detect complex patterns in behavior and attitudes, students can more effectively navigate the venture-startup process, transforming abstract ideas into viable business models (Medina-Vidal et al., 2025). This heightened alertness is further supported by immersive virtual learning environments, which, when combined with generative AI, significantly improve awareness of digital economic concepts and produce sustainable digital products (Abdelmagid et al., 2025). Unlike digital self-efficacy, which primarily reflects an individual's confidence in performing technology-related tasks, entrepreneurial alertness captures the cognitive ability to recognize, interpret, and exploit emerging opportunities. In AI-enabled environments, opportunity recognition may become increasingly important, as intelligent technologies can assist users in executing tasks but cannot fully replace human judgment in determining which opportunities are worth pursuing. Consequently, entrepreneurial alertness remains a critical mechanism through which educational ecosystems translate technological exposure into entrepreneurial outcomes.

Furthermore, e-learning environments may contribute to competency development by continuously exposing students to market information, innovation trends, collaborative projects, and real-world entrepreneurial challenges. Such exposure strengthens the ability to recognize opportunities and encourages students to connect technological possibilities with practical business applications. Therefore, entrepreneurial alertness represents not merely an individual trait but a dynamic cognitive outcome fostered through interactions between learners, digital platforms, and emerging technologies. Ultimately, in an era where technology is inseparable from business, maintaining entrepreneurial alertness requires a seamless integration of technical proficiency with cognitive agility to exploit emerging digital tools (Utama et al., 2026).

Conceptualizing Technopreneurship Competency in the Global South

Technopreneurship competency in the Global South, particularly within the Indonesian archipelago, is increasingly defined as a multidimensional construct that harmonizes traditional entrepreneurial acumen with sophisticated digital proficiency. It is no longer sufficient for graduates to possess mere managerial skills; they must now demonstrate the ability to create technology-based business solutions that are both adaptive and innovative (Utama et al., 2026). This hybrid competency combines entrepreneurial skills with technology to drive digital transformation and innovation. Within the specific socio-economic context of Indonesia, this development is deeply intertwined with curriculum transformation efforts that seek to integrate artificial intelligence into the pedagogical fabric of higher education (Khoza, 2026). Beyond technical proficiency, contemporary technopreneurship competency increasingly encompasses the ability to collaborate effectively with intelligent technologies. In the era of generative AI, competency is not solely reflected in what individuals know or can independently perform, but also in their capacity to leverage AI-supported insights, generate innovative solutions, evaluate technological outputs critically, and transform digital recommendations into entrepreneurial value. This perspective expands the traditional understanding of competency from individual capability toward a more dynamic form of human-AI augmented performance.

However, conceptualizing these competencies in a developing nation requires an acknowledgment of the unique systemic hurdles that characterize the regional digital landscape. While the Fourth Industrial Revolution offers a path to leapfrogging traditional economic stages, implementing technology-based education is often hampered by a significant digital divide. Challenges such as restricted internet access in remote regions, a lack of high-quality data, and inadequate regulatory frameworks complicate the uniform development of technopreneurial skills. Consequently, technopreneurship in this context is as much about resilience and resourcefulness as it is about technical mastery. To be truly competent, Indonesian students must be prepared to navigate these infrastructural limitations while simultaneously optimizing emerging tools like generative AI for value creation (Jiang, 2026).

Furthermore, the increasing accessibility of generative AI may partially reduce traditional barriers associated with knowledge acquisition, business planning, and opportunity evaluation. As a result, technopreneurship competency may emerge not only from accumulated human capital but also from the effective orchestration of technological resources that augment entrepreneurial decision-making. Such a perspective is particularly relevant in the Global South, where intelligent technologies can help address resource constraints and accelerate the

development of entrepreneurial capabilities. This holistic approach ensures that innovation and entrepreneurship education remain relevant to industry needs in a digital age, ultimately producing graduates capable of contributing to a sustainable, inclusive green digital economy (Abdelmagid et al., 2025).

Hypotheses Formulation and Research Framework

The primary catalyst in this model is the utilization of Artificial Intelligence (AI), which serves as a cognitive engine for innovation. Preliminary evidence suggests that AI utilization significantly drives technopreneurial outcomes, with a regression coefficient indicating a dominant role in students' digital transformation. This is corroborated by contemporary findings showing that AI-related digital competencies are essential for shaping fintech entrepreneurial intentions (Wach et al., 2026). Similarly, e-learning systems provide the necessary structural ecosystem, facilitating flexible knowledge acquisition that supports sustainability-oriented ventures (Ha et al., 2025). While the direct influence of e-learning may appear less pronounced than that of AI, its role in creating an interactive learning environment remains statistically significant. Beyond its traditional role as a supportive technology, generative AI may also serve as an active cognitive resource, reducing barriers to entrepreneurial problem-solving and opportunity evaluation. Consequently, AI may influence competency development through both direct and indirect pathways. While existing theories emphasize psychological mediation mechanisms, recent advances in intelligent systems suggest that certain competency outcomes may emerge directly from human–AI interaction.

The transition from technological exposure to tangible competency is rarely a linear process; internal psychological states often mediate it. Digital self-efficacy (DSE) is the student's confidence in navigating complex digital terrain and serves as a domain-specific construct within the theory of planned behavior (Wach et al., 2026). Furthermore, technological trust and perceived personal capability dictate whether an individual perceives international entrepreneurship as feasible and desirable (Duong, 2025). In parallel, the emergence of generative AI enhances entrepreneurial alertness—the ability to scan and exploit market opportunities (Akçaba et al., 2026). This cognitive dexterity is crucial for producing sustainable digital products in the green digital economy (Abdelmagid et al., 2025). Nevertheless, the increasing accessibility and intuitive nature of generative AI raise the possibility that some users may engage in entrepreneurial activities before fully developing strong self-efficacy beliefs or formal entrepreneurial intentions. This possibility does not negate the relevance of psychological mediators but suggests that their influence may vary depending on the degree to which intelligent technologies compensate for limitations in knowledge, experience, and confidence.

Finally, the efficacy of these technological and cognitive factors depends on contextual moderators. The institutional environment, characterized by an Islamic Technopreneurial culture, may provide the ethical and motivational grounding required for digital resilience. Moreover, the baseline level of digital literacy acts as a filter; students with higher levels of literacy are better equipped to leverage e-learning to achieve innovative outcomes. Finally, the alignment between specific AI tools and the Learning Management System (LMS) ensures that technological support translates into stable business estimations (Duong, 2025). Within this framework, contextual conditions are expected to shape not only the effectiveness of technological adoption but also the extent to which AI-driven competency formation occurs through direct or indirect mechanisms. Therefore, institutional, technological, and literacy-related factors remain important boundary conditions in understanding technopreneurship development in higher education. Based on these interactions, we propose:

- H1: AI utilization significantly and positively influences technopreneurship competency.
- H2: E-learning systems significantly and positively influence technopreneurship competency.
- H3: AI utilization significantly enhances digital self-efficacy.
- H4: E-learning systems significantly increase entrepreneurial alertness.
- H5: AI adoption significantly influences entrepreneurial intention.
- H6: Digital self-efficacy mediates the relationship between AI utilization and technopreneurship competency.
- H7: Entrepreneurial alertness mediates the Path from e-learning systems to technopreneurship competency.
- H8: Entrepreneurial intention mediates the influence of AI adoption on practical competency.
- H9: There is a serial mediation in which AI utilization increases digital self-efficacy, which in turn bolsters entrepreneurial intention, leading to higher technopreneurship competency.
- H10: Islamic Technopreneurial culture significantly moderates (strengthens) the relationship between AI utilization and technopreneurship competency.
- H11: Digital literacy significantly moderates the effect of e-learning systems on entrepreneurial innovation.

H12: The alignment between AI tools and LMS features moderates the impact of technology on entrepreneurial resilience.

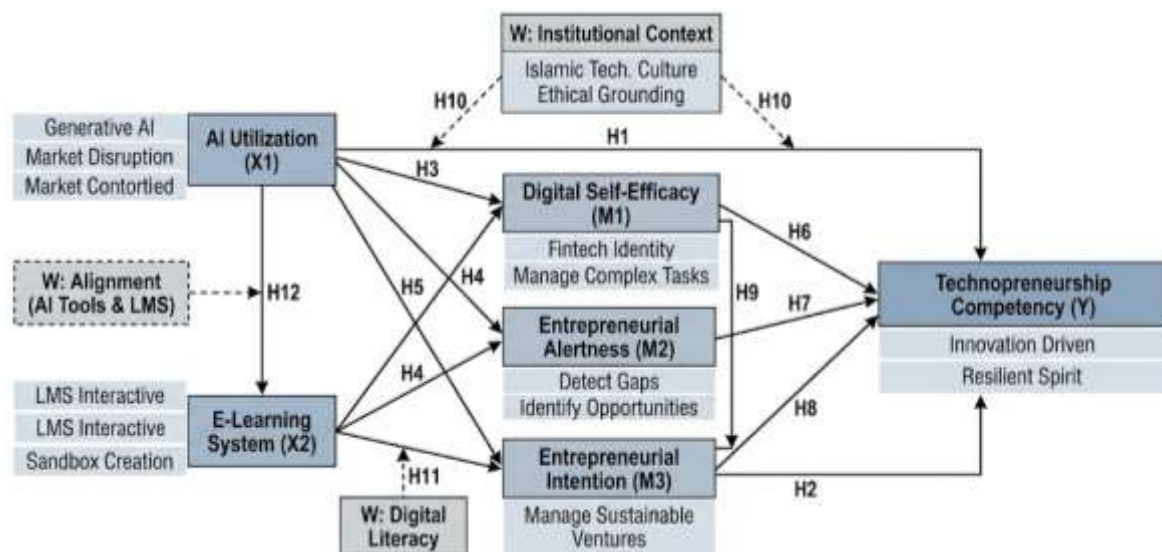


Figure 1. Proposed Research Framework

Source: Research data, 2026

The structural model integrates the technological exogenous variables (X1, X2), the cognitive mediators (M1, M2, M3), and the contextual moderators (W) to explain the variance in Technopreneurship Competency (Y).

C. METHODS

The investigation targets undergraduate students within the management discipline in Indonesia, specifically the 2022 cohort. This demographic is chosen because they occupy a critical transition phase between professional competency development and labor market readiness. Data were collected from 168 respondents through a systematic cross-sectional survey in 2026. While the sample size is relatively concentrated, the application of PLS-SEM via SmartPLS 4 remains robust due to its high statistical power in analyzing complex models with smaller datasets and non-normal distributions. To further verify sample adequacy, a post-hoc statistical power analysis was conducted following the recommendations of (Cohen, 1988; J. Hair et al., 2022). Using a significance level of $\alpha = 0.05$, a medium effect size ($f^2 = 0.15$), and the maximum number of predictors directed toward an endogenous construct in the structural model, the statistical power exceeded the recommended threshold of 0.80, reaching approximately 0.98. This result indicates that the sample size of 168 respondents was sufficient to detect meaningful relationships among the study variables while minimizing the risk of Type II error.

Measurement scales were adapted from established literature and refined to fit the Indonesian academic context. All constructs were measured using a 5-point Likert scale to ensure granular response variance. Artificial Intelligence Utilization (X1) encompasses the integration of generative tools like ChatGPT and Gemini for strategic tasks. E-Learning Systems (X2) are evaluated based on the interactivity and structured engagement of Learning Management Systems (LMS). The dependent variable, Technopreneurship Competency (Y), is operationalized through indicators of innovative business solution creation and technological integration.

Table 1. Operational Definition and Indicator Mapping

Variable	Indicators	Supporting Literature
AI Utilization (X1)	Chatbot usage, data analysis tools, and AI for creative design.	Wach et al. (2026); Mwaanga et al. (2026).
E-Learning System (X2)	LMS interactivity, synchronous platforms, and digital structuredness.	Sumenep et al. (2023); Malang et al. (2025).
Digital Self-Efficacy (M1)	Technical confidence, AI-fintech identity, complex task management.	Wach et al. (2026); Ha et al. (2025).

Variable	Indicators	Supporting Literature
Entrepreneurial alertness (M2)	Opportunity scanning, market gap detection, and innovative foresight.	Akçaba et al. (2026); Rahal et al. (2026).
Technopreneurship Comp. (Y)	Strategic decision-making, digital venture resilience, solution-oriented innovation.	Utama et al. (2026); Khoza (2026).

Source: Research data, 2026

The analysis follows a two-stage evaluation process to ensure the integrity of the findings. First, the Measurement Model (Outer Model) assessment determines the reliability and validity of the constructs. Beyond traditional Cronbach's Alpha, this study utilizes the Heterotrait-Monotrait (HTMT) ratio to establish superior discriminant validity. Second, the Structural Model (Inner Model) testing assesses the significance of the path coefficients and the model's explanatory power using R2 and Q2 values. To fulfill the practical requirement, an Importance-Performance Map Analysis (IPMA) is conducted. This technique prioritizes variables by comparing their total effect (Importance) against their average scores (Performance), providing actionable insights for Indonesian university administrators.

Table 2. Statistical Evaluation Criteria for PLS-SEM

Analysis Stage	Measurement Metric	Threshold	Reference Source
Measurement Model	Cronbach's Alpha & Composite Reliability (CR)	> 0.70	Hair et al. (2022)
	Average Variance Extracted (AVE)	> 0.50	Fornell & Larcker (1981)
	Discriminant Validity (HTMT)	< 0.85 (Strict) or 0.90 (Liberal)	Henseler et al. (2015)
Structural Model	Path Coefficients (β)	$p < 0.05$ or $t > 1.96$ (Two-tailed)	Hair et al. (2019); Hair et al. (2022)
	Coefficient of Determination (R ²)	0.25 (Weak), 0.50 (Mod), 0.75 (Subst)	Cohen (1988); Hair et al. (2011)
	Predictive Relevance (Q ²)	> 0	Geisser (1974); Stone (1974)
	Effect Size (f ²)	0.02 (Small), 0.15 (Med), 0.35 (Large)	Cohen (1988)
	Statistical Power	> 0.80	Cohen (1988)

Source: Research data, 2026

Sample Size Adequacy and Statistical Power

The adequacy of the sample size was assessed using both methodological and statistical criteria. From a methodological perspective, PLS-SEM is recognized as an appropriate analytical approach for complex predictive models involving multiple latent constructs and mediation pathways, particularly when sample sizes are moderate (J. Hair et al., 2022). The sample of 168 respondents exceeded the minimum requirements suggested by the ten-times rule and current PLS-SEM recommendations. To provide additional empirical support, a post-hoc statistical power analysis was performed. Assuming a medium effect size ($f^2 = 0.15$), a significance level of 5%, and the maximum number of predictors directed toward an endogenous construct, the estimated statistical power was approximately 0.98. This value substantially exceeds the minimum threshold of 0.80 recommended for behavioral and social science research (Cohen, 1988), confirming that the sample size was sufficient to identify statistically significant effects within the proposed structural model.

D. RESULTS AND DISCUSSIONS

Descriptive Analysis and Respondent Profile

The study successfully collected data from 168 valid respondents, yielding a robust sample that meets the requirements for a high-power PLS-SEM analysis. The adequacy of this sample was further confirmed through a post-hoc statistical power analysis, which yielded a power value exceeding the recommended threshold of 0.80, indicating sufficient statistical sensitivity to detect meaningful relationships within the proposed structural model. The gender distribution is relatively balanced: 52.4% females (88 respondents) and 47.6% males (80 respondents). This gender-neutral participation is vital to ensuring that subsequent findings on digital self-efficacy and technopreneurial intention are not skewed by gender-specific biases, a factor increasingly emphasized in contemporary entrepreneurship research in the Global South.

Age and academic standing further define the cohort's profile. A significant majority, 60.1% (101 respondents), fall within the 21–22 age bracket, while 30.4% (51 respondents) are aged 19–20, and a smaller fraction (9.5%) are aged 23 or older. This distribution aligns with academic enrollment status: 75.6% (127 respondents) are currently in Semester 6, and 24.4% (41 respondents) are in Semester 4. This dominance of senior-level students is strategically significant; these individuals have typically completed core entrepreneurship modules and are actively contemplating their transition into the workforce or venture creation. Background factors such as academic performance and prior business experience provide the baseline for technopreneurial potential. The GPA scores range from 2.77 to 4.00, with a substantial cluster of students achieving scores above 3.50, indicating a high level of academic rigor among the participants. Furthermore, 33.9% (57 respondents) reported having prior business experience, whereas 66.1% (111 respondents) have not yet engaged in formal venture activities. This split is particularly insightful for Indonesian universities, as it highlights a large pool of potential technopreneurs with the academic foundation but who may require the specific cognitive engine provided by AI and e-learning systems to trigger their first business launch.

Table 3. Summary of Respondent Demographics (N=168)

Category	Classification	Frequency	%
Gender	Male	80	47.6
	Female	88	52.4
Age	19–20 Years	51	30.4
	21–22 Years	101	60.1
	>22 Years	16	9.5
Academic Level	Semester 4	41	24.4
	Semester 6	127	75.6
Business Experience	Yes	57	33.9
	No	111	66.1

Source: Research data, 2026

These demographic markers suggest a mature, academically competent respondent pool capable of providing nuanced feedback on the integration of digital tools in their learning journey. The high percentage of Semester 6 students ensures that the data reflect a stage of development where technopreneurial alertness and intention are closest to real-world application. Furthermore, the combination of strong academic performance and limited prior business experience among many respondents provides an appropriate context for examining how AI utilization and e-learning ecosystems contribute to the development of technopreneurship competency. This profile is particularly relevant for investigating whether emerging technologies can accelerate competency acquisition beyond conventional psychological and experiential pathways.

Measurement Model Assessment

The reliability and validity of the constructs were evaluated using stringent statistical benchmarks. For a high-level discourse, particularly within the Indonesian academic context, it is imperative to establish that the observed indicators accurately reflect their underlying latent variables before proceeding to structural testing. In addition, the adequacy of the sample size and the satisfactory statistical power reported in the methodological assessment provide further confidence in the stability of the measurement estimates. As synthesized in Table 4, the measurement model exhibits robust integrity across all dimensions.

Individual item reliability is confirmed by outer loadings, which show that all primary indicators for AI utilization, e-learning systems, and technopreneurship competency exceed the 0.708 threshold, indicating that each item explains more than 50% of its indicator's variance. Specifically, AI utilization (0.799–0.859) and e-learning systems (0.825–0.867) show strong alignment between the technological tools used and students' perceptions of their utility. Internal consistency is further supported by Cronbach's Alpha and Composite Reliability (CR) values ranging from 0.835 to 1.000, well above the 0.70 threshold. Furthermore, the Average Variance Extracted (AVE) for all constructs exceeds 0.668, confirming substantial convergent validity, as the latent variables account for a majority of the variance in their indicators.

Table 4. Consolidated Measurement Model Results

Construct (Alpha; CR; AVE)	Item	Measurement Statement	Loading
	AI1	Utilizing AI for business modeling and strategic planning.	0.856

Construct (Alpha; CR; AVE)	Item	Measurement Statement	Loading
AI Utilization (α : 0.857; CR: 0.903; AVE: 0.700)	AI2	Employing AI tools for market data analysis.	0.799
	AI3	Using generative AI for professional content creation.	0.859
	AI4	Optimizing operational efficiency through AI automation.	0.831
E-Learning Systems (α : 0.871; CR: 0.912; AVE: 0.721)	EL1	Engaging with an interactive LMS for entrepreneurship courses.	0.867
	EL2	Participating in real-time digital collaborative projects.	0.866
	EL3	Navigating structured digital learning pathways.	0.839
	EL4	Utilizing user-friendly and accessible digital platforms.	0.825
Digital Self-Efficacy (α : 0.861; CR: 0.906; AVE: 0.706)	DSE1	Confidence in managing complex digital business tasks.	0.840
	DSE2	Self-reliance in mastering new software tools.	0.839
	DSE3	Belief in achieving business success via digital skills.	0.835
	DSE4	Ability to solve technical challenges independently.	0.847
Entrepreneurial Alertness (α : 0.849; CR: 0.898; AVE: 0.688)	EA1	Identifying emerging market gaps through digital trends.	0.857
	EA2	Recognizing digital industry shifts as opportunities.	0.828
	EA3	Spotting innovative niches in the tech-based economy.	0.803
	EA4	Maintaining foresight regarding tech-disruptions.	0.830
Entrepreneurial Intention (α : 0.835; CR: 0.889; AVE: 0.668)	EI1	Intention to launch a digital venture upon graduation.	0.812
	EI2	Professional goal directed toward tech-entrepreneurship.	0.830
	EI3	Active planning for a technology-based business.	0.820
	EI4	Personal commitment to developing a digital start-up.	0.806
Islamic Tech. Culture (α : 0.847; CR: 0.897; AVE: 0.685)	ITC1	Integrating Islamic ethical values in business innovation.	0.857
	ITC2	Prioritizing social impact (ummah) through technology.	0.857
	ITC3	Balancing religious principles with tech-entrepreneurship.	0.837
	ITC4	Applying ethical guidelines to digital business practices.	0.755
Technopreneurship Comp. (α : 0.866; CR: 0.908; AVE: 0.712)	TC1	Strategic integration of AI in business operations.	0.833
	TC2	Demonstrating resilience in digital business environments.	0.871
	TC3	Synergizing technical skills with entrepreneurial action.	0.853
	TC4	Executing innovative solutions using digital ecosystems.	0.819

Source: Research data, 2026

The consistently high outer loadings, reliability coefficients, and convergent validity statistics indicate that the measurement instruments adequately capture both technological and psychological dimensions of technopreneurship development. This is particularly important given the study's objective of examining direct and indirect pathways linking AI utilization, e-learning ecosystems, and competency formation. The strong psychometric properties reduce the likelihood that subsequent structural relationships are influenced by measurement error. Discriminant validity was assessed using the Heterotrait-Monotrait (HTMT) ratio, which is the current gold standard for establishing that constructs are empirically distinct. As shown in Table 5, all HTMT values are below the strict threshold of 0.85 or the more liberal threshold of 0.90. The highest correlation is observed between AI utilization and technopreneurship competency (0.808), yet it remains well within the acceptable range. This confirmation enables distinct interpretations of technological, cognitive, and cultural variables within the structural model.

Table 5. Discriminant Validity Results (HTMT Ratio)

	AI	DL	DSE	EL	EA	EI	ITC	TC
Digital Literacy	0.610							
Digital Self-Efficacy	0.709	0.510						
E-Learning Systems	0.447	0.631	0.381					
Ent. Alertness	0.487	0.393	0.436	0.611				
Ent. Intention	0.644	0.481	0.681	0.391	0.593			
Islamic Tech. Culture	0.261	0.309	0.365	0.151	0.447	0.481		
Tech. Competency	0.808	0.616	0.604	0.460	0.569	0.602	0.452	
Alignment (AI & LMS)	0.622	0.675	0.432	0.694	0.580	0.530	0.268	0.626

Source: Research data, 2026

The discriminant validity results are particularly noteworthy because they confirm the empirical distinctiveness of conceptually related constructs, including AI Utilization, Digital Self-Efficacy, Entrepreneurial Intention, and Technopreneurship Competency. This distinction is essential for accurately assessing whether AI-

driven competency formation occurs through traditional psychological mechanisms or through more direct pathways within the structural model. Meeting these measurement criteria confirms that the proposed variables are robust and reliable. Consequently, the analysis can proceed to evaluate the structural relationships and the hypothesized mediation and moderation paths. The satisfactory measurement performance also provides a strong foundation for examining the theoretical proposition underlying this study: whether AI's influence on technopreneurship competency is primarily mediated by psychological constructs or operates through more direct competency-building mechanisms.

Structural Model Assessment

Prior to evaluating the structural relationships, a post-hoc statistical power analysis was performed to assess the adequacy of the sample size. Assuming a medium effect size ($f^2 = 0.15$), a significance level of $\alpha = 0.05$, and the maximum number of predictors directed toward an endogenous construct, the resulting statistical power was approximately 0.98. This value exceeds the recommended threshold of 0.80 (Cohen, 1988), confirming that the sample size of 168 respondents was sufficient to detect meaningful structural effects within the proposed model. Before interpreting the structural paths, the model was screened for lateral collinearity by examining the inner Variance Inflation Factors (VIFs). All inner VIF scores remain well below the conservative threshold of 3.0, with the highest value recorded at 1.940 for the Path leading to Technopreneurship Competency. This confirms that the predictor variables are not redundant and that the structural coefficients are not biased by multicollinearity. The model's explanatory power is reflected in the Coefficient of Determination (R^2). The results indicate that integrating technological, cognitive, and cultural variables explains 57.6% of the variance in Technopreneurship Competency ($R^2 = 0.576$). According to the criteria established by J. F. Hair et al. (2011), this provides substantial explanatory power for behavioral research. Additionally, the predictive relevance was assessed using the Blindfolding procedure, yielding a Q^2 value of 0.395 for the primary endogenous construct. Since $Q^2 > 0$, the model demonstrates robust out-of-sample predictive relevance, reinforcing the stability of the findings within the Indonesian context.

The structural paths were tested using a bootstrapping procedure with 5,000 resamples to determine the significance of the 12 hypotheses. As detailed in Table 6, the empirical evidence reveals several dominant drivers of technopreneurial skill acquisition. Strikingly, AI utilization emerges as the most potent direct predictor of Technopreneurship Competency ($\beta = 0.531$, $t = 9.220$, $p < 0.001$), supporting H1. This finding suggests that, for Indonesian students, active engagement with AI tools provides the intellectual engine for innovation. Furthermore, AI utilization exerts a profound influence on internal psychological states, significantly bolstering Digital Self-Efficacy ($\beta = 0.568$, $p < 0.001$) and Entrepreneurial Intention ($\beta = 0.423$, $p < 0.001$), thereby validating H3 and H5. This finding is particularly noteworthy because the magnitude of the direct effect substantially exceeds the influence of several intermediate psychological mechanisms examined in the model. Such evidence suggests that AI may operate not only as a learning-support technology but also as an active competency-enabling resource, enabling students to engage directly in entrepreneurial problem-solving, business ideation, and strategic decision-making. In contrast, while E-learning systems do not show a direct significant impact on intention, they play a vital role in sharpening Entrepreneurial Alertness ($\beta = 0.427$, $t = 6.606$, $p < 0.001$), supporting H4. This alertness subsequently translates into tangible competency ($\beta = 0.161$, $p = 0.004$), highlighting the structural role of e-learning in providing the analytical framework for opportunity identification. Interestingly, the alignment between AI tools and LMSs is a critical precursor of e-learning efficacy ($\beta = 0.564$, $p < 0.001$), suggesting that the technical synergy of university platforms is paramount for student engagement.

Table 6. Structural Model Results and Hypothesis Testing (N=168)

Hyp.	Relationship	β	T-Stat	P-Value	f^2	Decision
H1	AI Utilization → Tech. Competency	0.531	9.220	0.000	0.365	Supported
H3	AI Utilization → Digital Self-Efficacy	0.568	8.786	0.000	0.444	Supported
H4	E-Learning Systems → Ent. Alertness	0.427	6.606	0.000	0.232	Supported
H5	AI Utilization → Ent. Intention	0.423	4.989	0.000	0.194	Supported
H10	Islamic Tech. Culture → Tech. Competency	0.178	3.051	0.002	0.057	Supported
H12	Alignment (AI & LMS) → E-Learning	0.564	8.648	0.000	0.371	Supported

Note: Results for mediation and non-significant paths are discussed in the subsequent analysis. Source: Research data, 2026

The effect size analysis provides deeper insight into the practical impact of each variable. AI utilization demonstrates a large effect size ($f^2 = 0.365$) on competency and an even larger effect on digital self-efficacy (f^2

= 0.444). This reinforces the notion that AI is not merely an auxiliary tool but a transformative core component of modern pedagogy. The alignment between AI and LMS also exhibits a large effect ($f^2 = 0.371$), while Islamic Technopreneurial Culture and Entrepreneurial Alertness show small-to-medium effects, suggesting they serve as important supplementary drivers for the overall model.

Mediation and Moderation Analysis

The results of the mediation analysis, summarized in Table 7, provide a nuanced perspective on how technology translates into student competency. While AI utilization has a dominant direct effect, its indirect paths through psychological bridges show varying degrees of significance. Entrepreneurial Alertness (EA) emerges as the most robust mediator in the model. Specifically, the Path from E-learning systems → EA (Technopreneurship Competency) is statistically significant ($\beta = 0.069$, $t = 2.735$, $p = 0.006$), supporting H7. This suggests that e-learning platforms in Indonesia are particularly effective when they sharpen students' ability to scan for market opportunities rather than deliver technical content. In contrast, the mediation roles of Digital Self-Efficacy (H6) and Entrepreneurial Intention (H8) were not supported, with p-values of 0.375 and 0.521, respectively. While traditional TPB-based explanations would suggest that technological exposure should first enhance self-efficacy and entrepreneurial intention before influencing competency, the present findings indicate a different pattern. Specifically, AI utilization significantly strengthens both Digital Self-Efficacy and Entrepreneurial Intention, yet neither construct significantly transmits the effect of AI toward Technopreneurship Competency.

One plausible explanation lies in the unique characteristics of generative AI systems. Unlike conventional digital technologies, which require extensive expertise before meaningful outcomes can be achieved, generative AI embeds analytical, creative, and problem-solving capabilities directly within the system. As a result, students may perform complex entrepreneurial tasks through interaction with AI tools even when self-confidence and formal entrepreneurial intentions are still developing. In this context, intelligent technologies partially compensate for limitations in experience, knowledge, and perceived capability, thereby reducing dependence on traditional psychological mediation mechanisms. These findings provide empirical support for what may be described as a Direct-Action Paradox, in which AI simultaneously strengthens psychological readiness while rendering it less critical as an intermediary pathway toward competency acquisition. Rather than replacing human cognition, AI appears to augment and accelerate competency formation through direct human-AI collaboration.

Table 7. Specific Indirect Effects

Hyp.	Relationship Chain	Indirect Path (β)	T-Stat	P-Value	Decision
H6	AI → DSE → Tech. Competency	0.034	0.887	0.375	Not Supported
H7	EL → EA → Tech. Competency	0.069	2.735	0.006	Supported
H8	AI → EI → Tech. Competency	0.017	0.642	0.521	Not Supported
H9	AI → EL → EA → Tech. Competency	0.005	0.914	0.361	Not Supported

Source: Research data, 2026

The moderation analysis reveals the model's conditional nature. While Islamic Technopreneurial Culture (H10) and Digital Literacy (H11) were found to be significant direct predictors or moderately influential, they did not serve as classical moderators in this specific structural configuration. However, Moderating Effect 3, representing the interaction between Alignment (AI & LMS) and Entrepreneurial Intention, was significant ($\beta = -0.097$, $p = 0.003$), supporting H12. This negative interaction coefficient is particularly revealing for the Indonesian higher education context. It suggests that while alignment is generally beneficial, an over-reliance on perfectly aligned, locked-in university systems might slightly dampen the raw entrepreneurial intention of highly motivated students who prefer exploring decentralized AI tools outside the formal LMS. Furthermore, the Total Effects analysis confirms that AI Utilization remains the undisputed anchor of the entire model, with a total impact score of 0.630 ($p < 0.001$), nearly 8 times that of e-learning systems (0.079).

Table 8. Summary of Moderation and Total Effects

Relationship	Total effect (β)	T-Stat	P-Value	Impact Level
AI Utilization → Tech. Competency	0.630	16.802	0.000	Very Large
E-Learning → Tech. Competency	0.079	2.905	0.004	Small
Alignment → Tech. Competency	0.044	2.675	0.008	Small
Mod Effect 3 → Ent. Intention	-0.097	3.023	0.003	Significant

Source: Research data, 2026

The findings underscore a Direct-Action profile among Indonesian students: they leverage AI as a primary tool for competence acquisition, whereas structured e-learning and institutional culture provide the necessary, albeit secondary, environmental support. More importantly, the results suggest that competency development in AI-enabled educational environments may no longer follow exclusively sequential psychological pathways. While Digital Self-Efficacy and Entrepreneurial Intention remain important outcomes of AI adoption, their role as mediators appears to diminish when intelligent technologies provide immediate access to analytical support, opportunity exploration, and business ideation capabilities. Consequently, the findings indicate a subtle redistribution of cognitive agency between learners and intelligent technologies. Under such conditions, competency emerges not only from what students know or believe they can accomplish, but also from their ability to collaborate with AI systems strategically. This observation provides a theoretical foundation for understanding the Direct-Action Paradox identified in this study and offers an alternative perspective on competency formation within the emerging landscape of AI-augmented higher education.

Importance-Performance Map Analysis (IPMA)

To provide actionable insights for Indonesian higher education administrators, an Importance-Performance Map Analysis (IPMA) was conducted. This diagnostic technique extends standard PLS-SEM results by contrasting the total effects of the structural model (Importance) with the rescaled mean scores of the latent variables (Performance) on a 0-100 scale (Ringle & Sarstedt, 2016). This dual-dimensional perspective identifies high-priority areas where a unit increase in performance would yield the most significant gains in Technopreneurship Competency. Importantly, the IPMA complements the structural findings by revealing not only which constructs exert the strongest influence on competency development but also where institutional interventions may generate the greatest practical impact.

Table 9. IPMA Results for Technopreneurship Competency

Construct	Total Effect (Importance)	Index Value (Performance)	Priority Level
AI Utilization	0.630	64.2	High Priority
E-Learning Systems	0.079	78.5	Maintenance
Entrepreneurial Alertness	0.161	72.1	Moderate
Islamic Tech. Culture	0.178	68.4	Moderate
Alignment (AI & LMS)	0.044	75.3	Low Priority

Source: Research data, 2026

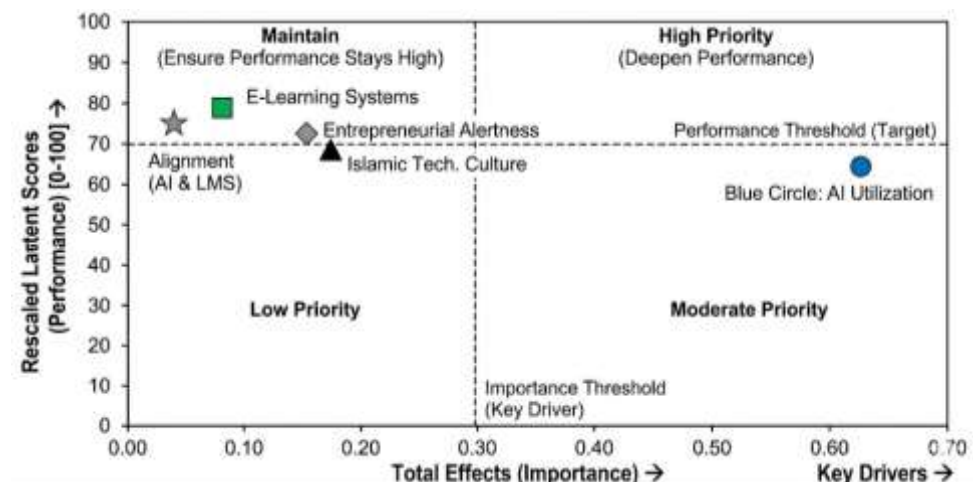


Figure 2. Importance-Performance Map Analysis (IPMA) for Technopreneurship Competency

Source: Research data, 2026

The IPMA results in Table 9, as visualized in Figure 2, highlight a critical strategic gap. AI Utilization exhibits the highest importance score (0.630), confirming its status as the primary engine for technopreneurial

development in the digital age. However, its performance score is relatively moderate (64.2), suggesting that, while students are increasingly reliant on AI, their proficiency in using these tools for high-level business modeling and strategic innovation remains suboptimal. This finding aligns with contemporary observations in the Global South, where a digital divide often exists between basic access to technology and sophisticated professional applications (Khoza, 2026). Conversely, E-learning systems demonstrate a high performance score (78.5), reflecting the successful widespread adoption of LMS platforms across Indonesian universities. However, its importance score is strikingly low (0.079), indicating that current digital learning ecosystems have reached a point of diminishing returns in fostering technopreneurial skills directly. Similarly, Digital Literacy and Alignment (AI & LMS) show high performance but low total importance for the final competency outcome. This result reinforces the interpretation that e-learning systems function primarily as enabling infrastructures rather than direct competency drivers. Their contribution appears to be concentrated in supporting entrepreneurial alertness and facilitating opportunity recognition rather than independently generating technopreneurial capability. Consequently, additional investments in conventional LMS functionality may yield smaller marginal returns compared with investments that enhance AI-enabled learning experiences.

This observation is particularly noteworthy when viewed alongside the Direct-Action Paradox identified in the structural model. Although AI already exerts the greatest influence on competency development, its relatively low performance score indicates substantial unrealized potential. In other words, students appear to benefit from AI-assisted competency development even before achieving advanced mastery of these technologies. This finding suggests that improvements in strategic AI utilization could generate disproportionately large gains in technopreneurship competency. Taken together, the IPMA findings provide practical validation of the structural model results. While e-learning ecosystems demonstrate strong operational performance, AI utilization remains the most strategically important factor for improving technopreneurship competency. The combination of high importance and moderate performance positions AI as the primary target for institutional intervention, supporting a strategic transition from platform-centered digitalization toward AI-augmented entrepreneurship education.

Discussion

The most significant finding of this study is the undisputed dominance of AI utilization as the primary driver of technopreneurship competency (H1). With a path coefficient of 0.531 and a large effect size, AI has moved beyond a peripheral academic aid to become the central cognitive engine for innovation. These results align with recent Scopus-indexed findings that emphasize that AI knowledge significantly enhances business ideation more effectively than other emerging technologies, such as AR/VR or the Metaverse (Prabowo et al., 2025). In the Indonesian context, students leverage generative AI not merely for information retrieval but as a strategic ally for professional project conceptualization and market disruption (Medina-Vidal et al., 2025; Sánchez Gonzales et al., 2026). However, the IPMA reveals a critical Performance Gap. While AI is the most important factor, its current performance level (64.2) suggests that students are still at an early stage of mastering AI for complex business modeling. This identifies a strategic opportunity for Indonesian universities to move beyond basic digital literacy and toward deep integration of AI, focusing on fintech entrepreneurial intentions and AI-related digital competencies (Wach et al., 2026).

A distinctive contribution of this research is clarifying the role of e-learning systems. Unlike AI, e-learning does not exert a strong direct influence on final competency. Instead, it functions as a structural enabler that sharpens entrepreneurial alertness (H4, H7). The significant indirect Path through alertness indicates that well-structured LMS environments provide the analytical scaffolding students need to identify market gaps and recognize digital trends (Akçaba et al., 2026). This finding suggests that in Indonesia, the value of e-learning lies in its ability to facilitate a digital learning ecosystem in which opportunity identification is practiced in a safe, sandbox-like environment (Abdelmagid et al., 2025). Moreover, the robust influence of alignment on e-learning efficacy emphasizes that the technical synergy between various AI tools and the university's formal LMS is a prerequisite for student engagement. Without this technical harmony, the structural benefits of e-learning are likely to be lost.

One of the more surprising results is the lack of significant mediation through Digital Self-Efficacy (DSE) and Entrepreneurial Intention (EI). While literature often positions these as critical bridges (Mwaanga et al., 2026; Wach et al., 2026), the Indonesian data suggest a direct-action profile. Indonesian management students appear to leapfrog traditional psychological development phases; they adopt AI tools and immediately apply them to competency-building tasks without waiting for a significant shift in internal self-efficacy or formalized intention. This phenomenon may be attributed to the high perceived ease of use and immediate utility of generative AI

platforms. When the barrier to entry is low and the output is immediate, the traditional cognitive evaluation of feasibility and desirability becomes secondary to practical experimentation (Duong, 2025; Mwaanga et al., 2026). This highlights a unique behavioral trend in the Global South: technology is utilized as a pragmatic tool for survival and innovation, often outstripping the slower evolution of institutional psychological frameworks (Khoza, 2026).

This finding offers a deeper theoretical implication for the evolving relationship between humans and intelligent technologies. Traditional behavioral theories generally assume that individuals must first develop confidence, perceived capability, and behavioral intention before successfully engaging in entrepreneurial action. However, generative AI appears to alter this sequence by embedding analytical, creative, and problem-solving capabilities directly into the technological system. Rather than relying exclusively on internally developed psychological resources, students can access externalized cognitive support through AI-assisted interactions. Consequently, competency development may occur through immediate experimentation and task execution, even when self-efficacy and entrepreneurial intention remain comparatively underdeveloped. From this perspective, the Direct-Action Paradox does not imply that psychological mechanisms become irrelevant. Instead, it suggests that the role of these mechanisms is partially complemented by intelligent technologies that actively participate in the competency formation process. In other words, cognitive agency becomes distributed between learners and AI systems, creating a new pathway through which entrepreneurial competency can emerge in digitally augmented educational environments.

Finally, the significant influence of Islamic Technopreneurial Culture (H{10}) suggests that the institutional environment provides a vital ethical and motivational layer. For Indonesian universities, integrating religious principles into business innovation is not merely a branding exercise but a functional component that enhances resilience and social impact. This cultural alignment helps students navigate the digital economy by providing a sense of purpose that transcends pure profit-seeking and aligns with the broader mission of producing graduates who contribute to the ummah through sustainable digital products (Abdelmagid et al., 2025; Utama et al., 2026). However, the negative interaction observed in H{12} serves as a cautionary note. An over-structured institutional alignment might inadvertently dampen the raw, decentralized spirit of innovation. Universities must strike a delicate balance between providing a structured digital ecosystem and allowing students the freedom to explore the wild frontier of AI outside the formal curriculum (Wach et al., 2026). This balance is particularly important in higher education, where the objective is not merely to produce technically proficient AI users but to cultivate adaptive technopreneurs capable of exercising independent judgment in rapidly evolving digital markets. The challenge for universities is therefore not whether AI should be integrated into entrepreneurship education, but how to structure this integration to maximize competency development while preserving critical thinking, creativity, and entrepreneurial autonomy.

Despite these advantages, the findings also warrant caution regarding the potential emergence of AI dependency. While generative AI can accelerate opportunity exploration, business ideation, and strategic analysis, excessive reliance on AI-generated outputs may reduce opportunities for independent critical reflection and entrepreneurial judgment. Students may become increasingly efficient in producing solutions without necessarily developing a deep understanding of the underlying market dynamics, strategic reasoning, or risk assessment processes. Therefore, universities should approach AI integration as a complementary mechanism that augments human cognition rather than a substitute for entrepreneurial learning. Balancing AI-supported experimentation with reflective learning activities will be essential to developing sustainable, transferable entrepreneurial competencies.

Theoretical Contributions

The findings of this research offer several significant contributions to the theoretical landscape of management education and digital entrepreneurship, particularly within the context of the Global South. First, this study extends the Theory of Planned Behavior (TPB) by demonstrating a Direct-Action phenomenon in the adoption of emerging technologies. While traditional TPB models emphasize a linear progression from perceived behavioral control to intention and finally to behavior (Ajzen, 1991), our results suggest that the immediate utility and low barrier to entry of generative AI tools allow students to bypass formal intentional phases. This suggests that in highly volatile, digital-first environments, technological support acts as a proximal stimulus that can leapfrog traditional psychological mediators (Duong, 2025; Mwaanga et al., 2026). More importantly, this study provides empirical support for a Direct-Action Paradox in AI-enabled learning environments. Contrary to conventional TPB assumptions, competency formation may occur even when the mediating influence of Digital Self-Efficacy

and Entrepreneurial Intention is statistically weak. This finding suggests that generative AI does not merely influence behavioral antecedents; it actively participates in the competency-building process by embedding analytical, creative, and problem-solving capabilities within the technological system itself. Consequently, the study extends TPB by proposing that intelligent technologies may function as quasi-cognitive resources that partially redistribute agency between human actors and digital systems.

Second, the study redefines the role of e-learning systems within Human Capital Theory. Rather than viewing e-learning merely as a delivery mechanism for technical knowledge, this research positions it as cognitive scaffolding that facilitates Entrepreneurial Alertness. By demonstrating the significant indirect Path from e-learning to competency through alertness, we contribute to understanding how structured digital environments sharpen the entrepreneurial eye—the ability to scan and recognize opportunities amid technological disruption (Akçaba et al., 2026; Ekelund & Kirzner, 1974). This shifts the focus of human capital investment from content accumulation to the development of analytical foresight (Wach et al., 2026). This distinction is theoretically important because it demonstrates that different educational technologies contribute to competency development through different mechanisms. While AI primarily functions as a direct competency accelerator, e-learning systems indirectly strengthen opportunity recognition capabilities. Such findings enrich Human Capital Theory by highlighting the complementary roles of cognitive augmentation technologies and learning infrastructures in contemporary entrepreneurship education.

Third, integrating Islamic Technopreneurial Culture into the structural model provides a vital contextual contribution. By validating the influence of ethical and religious grounding on technopreneurial competency, this study challenges the Western-centric, profit-only view of entrepreneurship. We propose a more holistic Socio-Technical Innovation Model in which institutional values and social impact serve as essential motivational anchors that sustain digital resilience (Utama et al., 2026). This contribution is particularly relevant for universities in Indonesia and other emerging economies seeking to balance global technological trends with local cultural identity (Khoza, 2026). Finally, the identification of the Alignment (AI & LMS) construct offers a new technical dimension to the literature on educational technology. By demonstrating that the synergy between decentralized AI tools and formal university platforms is a critical precursor to learning efficacy, this research provides a theoretical basis for Platform Harmony in digital pedagogy. This highlights the need to view the digital learning ecosystem as an integrated whole rather than a collection of isolated tools (Abdelmagid et al., 2025). Collectively, these contributions support a broader conceptual shift from technology-assisted learning toward AI-augmented competency formation. Rather than treating digital technologies as passive educational tools, the findings suggest that intelligent systems increasingly operate as active participants within the learning ecosystem, shaping how entrepreneurial competencies are developed, applied, and sustained.

Managerial Implications

The empirical evidence derived from this structural model and the corresponding IPMA results provides a strategic roadmap for university administrators and policymakers in the Indonesian higher education sector. The most pressing implication is the necessity for a strategic pivot in resource allocation. As demonstrated by the IPMA, e-learning systems have reached a maintenance plateau, where further investment in basic digital infrastructure yields diminishing returns for technopreneurial competency. Instead, universities must prioritize improving the performance of AI use. This involves moving beyond mere AI access to integrating AI-related digital competencies into the core management curriculum to foster sophisticated fintech entrepreneurial intentions. However, universities should avoid interpreting these findings as a justification for unrestricted AI adoption. While AI demonstrates the highest strategic importance, excessive dependence on AI-generated outputs may inadvertently weaken students' independent analytical reasoning and entrepreneurial judgment. Institutional policies should therefore encourage responsible AI usage by combining AI-assisted learning with reflective assignments, critical evaluation exercises, and experiential entrepreneurial projects.

Furthermore, the significant influence of the alignment between AI tools and the LMS necessitates a technical overhaul of institutional platforms. University IT departments should transition from closed, proprietary ecosystems to open, interoperable frameworks that enable seamless synchronization of generative AI tools with formal learning pathways. This technical harmony ensures that the "intellectual engine" of AI is supported by the "analytical scaffolding" of structured e-learning, ultimately sharpening the entrepreneurial alertness required to identify market gaps. Administrators should focus on creating digital sandboxes where students can experiment with AI for business ideation within a secure academic environment. Such environments should be designed not

only to increase technical proficiency but also to cultivate the ability to critically assess AI-generated recommendations, identify potential biases, and make independent strategic decisions.

Lastly, the positive impact of Islamic Technopreneurial Culture suggests that Indonesian universities should leverage their unique institutional values as a competitive advantage. Rather than adopting a purely Western-centric technological approach, management programs should explicitly integrate ethical grounding and social impact (ummah) into their technopreneurship modules. This cultural anchoring not only fosters resilience but also ensures that technological innovation is balanced with religious and social responsibility, producing graduates who are not only technically competent but also ethically driven. Faculty development programs must also be realigned to ensure that lecturers are equipped to facilitate this high-level integration, moving from content deliverers to AI-augmented innovation facilitators. From a broader policy perspective, the findings suggest that the future competitiveness of higher education institutions will depend less on the availability of digital infrastructure and more on their ability to orchestrate productive human–AI collaboration. Universities that successfully balance technological capability, entrepreneurial agility, ethical responsibility, and critical thinking are likely to be better positioned to produce resilient technopreneurs who can thrive in increasingly AI-mediated economic environments.

E. CONCLUSION

The primary objective of this investigation was to elucidate the structural dynamics between technological ecosystems and technopreneurship competency within the Indonesian higher education sector. By employing a multi-path SEM-PLS model, this study has identified that the synergy between AI utilization and e-learning systems is not merely an additive process but a complex interplay of cognitive and structural factors. The most profound finding is the undisputed dominance of AI as the primary cognitive engine of innovation, exerting a transformative influence that far outweighs traditional digital infrastructure. Furthermore, the research highlights a "Direct-Action Paradox" unique to the Indonesian student population. While e-learning systems effectively sharpen entrepreneurial alertness, the transition to competency driven by AI frequently bypasses traditional psychological mediators such as digital self-efficacy and formalized intention. This suggests that the immediate utility and low barrier to entry of generative AI allow students to leapfrog traditional developmental phases. More importantly, the findings indicate that competency formation in AI-enabled learning environments may increasingly emerge through direct human–AI interaction rather than exclusively through sequential psychological processes. This observation contributes to the growing understanding that intelligent technologies can function as active competency-enabling resources within entrepreneurship education.

Additionally, the inclusion of Islamic Technopreneurial Culture underscores the importance of an ethical and motivational anchor for sustaining digital resilience in the Global South. Ultimately, the Importance-Performance Map Analysis (IPMA) underscores a critical strategic mandate: universities must shift their focus from maintaining basic e-learning frameworks toward deep-tier AI integration. Addressing the performance gap in AI utilization is essential for ensuring that students do not merely use technology for academic tasks but leverage it as a strategic tool for venture creation and market disruption. At the same time, the findings suggest that AI integration should be accompanied by pedagogical strategies that preserve critical thinking, entrepreneurial judgment, and independent decision-making. The future of technopreneurship education, therefore, lies not in replacing human cognition with intelligent systems, but in cultivating effective and responsible human–AI collaboration capable of generating sustainable entrepreneurial value.

Limitations and Future Research

Despite the robustness of the structural findings, this study is subject to several limitations that offer avenues for future inquiry. First, the sample was restricted to 168 management students from a specific cohort in Indonesia. While this provided a controlled environment for testing the technopreneurial model, future research should expand the sampling frame to include students from diverse disciplines, such as engineering and the creative arts, to examine cross-disciplinary variations in technology-driven innovation. Second, the study employed a cross-sectional design, capturing a snapshot of student perceptions at a single point in time. Future longitudinal studies are necessary to track the actual conversion of technopreneurial intention into real-world business launches.

Third, while the model integrated Islamic culture as a contextual moderator, further research could explore other institutional or regional variables—such as government policy support or local digital infrastructure

stability—to refine the external validity of the findings. Finally, as AI tools evolve from generative text to autonomous agents, future models should differentiate among types of AI interaction to better understand their distinct impacts on human-computer synergy in entrepreneurship education. Future research should also investigate the potential consequences of AI dependency, including its effects on critical thinking, opportunity evaluation, entrepreneurial judgment, and the sustainability of long-term competency. Such investigations would help determine whether AI primarily augments human capability or whether excessive reliance may create unintended constraints on entrepreneurial development.

Another limitation concerns the interpretation of the Direct-Action Paradox identified in this study. Although the findings suggest that AI may facilitate competency development beyond traditional psychological mediation pathways, the cross-sectional design does not allow for direct observation of how cognitive agency is distributed between learners and intelligent systems over time. Future studies may employ longitudinal, experimental, or mixed-methods approaches to examine the mechanisms by which AI-supported learning influences competency development and entrepreneurial behavior.

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