



AI Competencies and Lifelong Learning for Vocational Teachers: Evidence from Thailand

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Abstract

Background and Aim: Rapid advances in artificial intelligence require Thai vocational teachers to update their competencies. In the Eastern Economic Corridor (EEC), instructor upskilling is critical to workforce readiness. This study examined the dimensions of teachers' AI competencies and lifelong learning through exploratory factor analysis (EFA) and developed the expert-validated PIERI framework—Planning, Implementation, Evaluation, Reflection, and Improvement—to support professional development.

Materials and Methods: A convergent parallel mixed-methods design was employed. Qualitative characteristics were synthesized from interviews with 12 administrators and document analysis. Quantitative data from 504 vocational college personnel in Thailand's EEC were analyzed using EFA with principal component analysis and Promax rotation to validate a 174-indicator framework spanning cognitive, psychomotor, and affective domains. Subsequently, nine educational experts constructed and validated the operational PIERI framework.

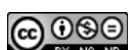
Results: Qualitative findings identified four characteristics of AI-competent vocational educators. EFA demonstrated sampling adequacy ($KMO = 0.953, p < .001$) and validated three domains, seven subcomponents, and 174 indicators, explaining 82.50% of cumulative variance. Domain-specific variance was 82.006% for cognitive, 83.139% for psychomotor, and 82.363% for affective competencies. The seven subcomponents comprised Computer/AI Fundamentals, Access, Use, Media Production, Communication, Media Management, and Evaluation. Expert connoisseurship validated the PIERI Model across five delivery modalities.

Conclusion: The findings establish an empirically supported framework for AI competencies and lifelong learning among Thai vocational teachers. By operationalizing competency dimensions through PIERI, the model offers a pathway for professional development. Institutional commitment to adaptation remains essential to strengthening teacher AI readiness, advancing national vocational standards, and supporting EEC workforce-development priorities.

Keywords: Artificial Intelligence Competencies, Vocational Teacher Development, Lifelong Learning, Exploratory Factor Analysis (EFA), PIERI Framework, Technical and Vocational Education and Training (TVET)

Introduction

The era of Education Disruption, under the next normal circumstances in Thailand and globally, has had a severe and continuous impact on vocational education organizations in terms of management and operations, and has triggered a quantum leap in educational policy changes at both national and international levels (Zhao & Ko, 2024; Riyanto et al., 2025). However, in reality, vocational education institutions face numerous problems and obstacles in achieving their goals, resulting in student efficiency and graduate quality remaining below standard, with competencies or learning outcomes potentially not aligning with 21st-century skills. Top-level administrators need to shift their thinking and adopt new management approaches that are responsive to change (Ahmed et al., 2023; Mambile &





Mwogosi, 2025), especially in the age of Artificial Intelligence Literacy, which requires comprehensive AI strategic planning covering all aspects of the organization. Fostering an AI culture, creating educational innovations, managing online education, and applying ICT systems are critical to enhancing core AI competencies and fostering lifelong learning, ultimately leading to education management for sustainability (Janthapass et al., 2024; Okwir, 2025; Pham Xuan & Håkansson Lindqvist, 2025). Senior administrators are directly responsible for the strategic management of vocational education institutions at every stage (Yadav, 2022; Jafari & Keykha, 2024).

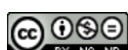
Within the Thai vocational education landscape, the Ministry of Education (2024) defines the quality standards for graduates across four essential dimensions: (1) Ethics, Morality, and Desirable Characteristics, (2) Knowledge, (3) Skills—including lifelong learning skills (Knight et al., 2023; Janthapass et al., 2024)—and (4) Application and Responsibility (Office of the Vocational Education Commission, 2017). To operationalize Thai Vocational Education 4.0, teachers serve as the vital catalysts who directly impact learner development. Vocational teachers must possess sufficient AI capability and knowledge to cultivate analytical, critical, creative, productive, and responsible thinking among students, ultimately leading to robust professional skills (Yadav, 2022; Holmes et al., 2022; Pansuwong et al., 2023; Saib et al., 2023; Marengo et al., 2024; Arias et al., 2025). As drivers of reform, vocational institution administrators and teachers are essential in creating a continuous learning society, decentralizing curriculum management, and deploying modern educational media (Sinlarat, 2020; Ahmed et al., 2023; Zhao & Ko, 2024; Mambile & Mwogosi, 2025; Tang et al., 2025). This need is particularly acute in high-growth economic zones such as the Eastern Economic Corridor (EEC), where manpower development must meet the dynamic demands of First S-curve and New S-curve industries. Meeting these industrial expectations demands technological capability, educational sandbox innovations, Work-integrated Learning, and continuous upskilling of educational personnel (Office of the National Economic and Social Development Board, 2017).

Currently, raising awareness and recognizing the importance of effective AI technology or ICT management is a crucial educational issue in the digital economy (Lee & Meng, 2021; Tang et al., 2025). Developing systematic ICT systems and AI data services makes higher and vocational education management significantly more efficient (Holmes et al., 2022; Oladimeji, 2023; Hao & Demir, 2024; Guo et al., 2025). Therefore, systematically evaluating and developing teachers' AI competencies and fostering lifelong learning in vocational institutions is imperative for sustainable institutional adaptation (Janthapass et al., 2024; Mahoney & Kiernan, 2024).

Building upon this contextual rationale, this study employs a rigorous, four-phase convergent parallel mixed-methods design to empirically investigate the structural components and operational development strategies for AI competencies and lifelong learning among vocational teachers in Eastern Thailand. Methodologically, the research systematically integrates qualitative baseline explorations from administrative in-depth interviews with large-scale quantitative verification to establish construct validity through Exploratory Factor Analysis (EFA) across a comprehensive set of indicators. Subsequently, through rigorous data triangulation and focus group connoisseurship with an expert panel, the study constructs and validates an actionable execution framework—the PIERI model—tailored to the dynamic industrial context of the Eastern Economic Corridor (EEC). By identifying qualitative characteristic domains, empirically confirming a tri-domain structural model (Cognitive, Psychomotor, and Affective), and operationalizing these findings through multi-modal strategies, this research provides robust, evidence-based mechanisms to inform national educational policy implementation (TVQF B.E. 2567), drive faculty professional development, and advance sustainable vocational education management.

Objectives

- 1) To identify the key characteristics of AI competencies and lifelong learning among vocational education teachers in Thailand
- 2) To analyze the structural components of AI competencies and lifelong learning capabilities within the Thai vocational education context.





3) To propose an empirical framework and strategies for fostering AI competencies and lifelong learning among vocational teachers.

Literature review

The rapid integration of Artificial Intelligence (AI) and Information and Communication Technology (ICT) into the global educational landscape has profoundly disrupted traditional vocational education paradigms. Navigating this era of educational disruption requires vocational institutions to dynamically adapt their management strategies and faculty readiness. In the context of Thailand, where vocational education serves as a pivotal driver for national economic development, establishing strong AI competencies and lifelong learning capabilities among vocational teachers is an urgent priority. This literature review synthesizes current research across four key dimensions: the impact of educational disruption on vocational education, the conceptualization of AI competencies for teachers, the role of lifelong learning in vocational education frameworks, and structural strategies for organizational and faculty development.

1. Educational Disruption and AI Integration in Vocational Education

The global transition toward digital economies and “Next Normal” educational environments has triggered a quantum leap in educational policy and management. Educational institutions worldwide face mounting pressure to align their instructional delivery with 21st-century learning demands. Zhao and Ko (2024) and Riyanto et al. (2025) emphasize that digital disruption necessitates comprehensive institutional reforms, particularly in how technology is embedded within curriculum execution and administrative decision-making. In vocational education, where practical, skills-based outcomes are paramount, the gap between traditional teaching methods and emerging industry expectations often results in graduate competencies falling below professional standards.

To bridge this gap, institutional leadership must embrace responsive management practices that prioritize technological integration. Ahmed et al. (2023) and Mambile and Mwogosi (2025) argue that academic leaders must shift away from conventional administrative models toward strategic planning that directly fosters an AI-oriented institutional culture. Furthermore, the deployment of robust ICT infrastructures and AI data services has been shown to significantly enhance organizational efficiency and learning outcomes in higher and vocational education settings (Oladimeji, 2023; Hao & Demir, 2024; Guo et al., 2025).

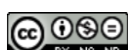
2. Conceptualizing AI Competencies for Vocational Educators

As Artificial Intelligence becomes increasingly ubiquitous in education, teachers are expected to evolve from traditional content deliverers into tech-empowered facilitators. AI competencies for educators extend beyond basic computer literacy; they encompass a multi-dimensional construct involving cognitive understanding, technical skills, critical evaluation, and ethical application.

Scholars emphasize that vocational teachers must cultivate high levels of AI literacy to foster critical thinking, problem-solving, and creative innovation among their students (Holmes et al., 2022; Saib et al., 2023; Marengo et al., 2024; Arias et al., 2025). According to Pansuwong et al. (2023) and Tang et al. (2025), teacher AI competency comprises multiple interrelated sub-dimensions, including: 1) Access and Usage: The ability to navigate and operate AI-driven tools and media effectively; 2) Creation and Communication: The capacity to produce AI-generated learning materials and communicate through modern technological channels; and 3) Management and Evaluation: The skill to manage digital learning assets and critically assess the pedagogical utility and validity of AI outputs. Establishing these core competencies enables vocational educators to design flexible, technology-enhanced learning environments that cater to modern workplace demands.

3. Lifelong Learning and the Thai Vocational Context

In an era of relentless technological acceleration, lifelong learning serves as an indispensable cornerstone of modern pedagogy. For vocational educators, engaging in continuous learning is no longer merely a personal aspiration; it is both a professional obligation and a systemic necessity to guard against technical skill obsolescence. As emphasized by Knight et al. (2023) and Janthapass et al. (2024), self-directed upskilling and fluid adaptiveness are vital indicators of teacher professionalism, particularly within rapidly changing technical disciplines.





In Thailand, this imperative for continuous faculty development is formally integrated into national policy agendas. Specifically, the Ministry of Education (2024) codifies standards for both graduates and instructors across four foundational domains: (1) Ethics, Morality, and Desirable Characteristics, (2) Knowledge, (3) Skills—which explicitly subsumes lifelong learning capability—and (4) Application and Responsibility (Office of the Vocational Education Commission, 2017). Furthermore, targeted regional initiatives like the Eastern Economic Corridor (EEC) compel vocational personnel to dynamically recalibrate their instructional methods to align with the evolving demands of First S-Curve and New S-Curve industries. This strategic alignment is operationalized through mechanisms such as educational sandbox innovations and Work-Integrated Learning (WIL) models (Office of the National Economic and Social Development Board, 2017).

4. Frameworks for Teacher Competency Development

Developing Artificial Intelligence (AI) competencies and fostering lifelong learning among vocational educators requires a transition from isolated, ad-hoc training workshops to institutionalized, systematic execution frameworks. Professional development yields the greatest efficacy when embedded within structured operational cycles that systematically integrate action, critical evaluation, and iterative refinement. In this regard, Sinlarat (2020), Lee and Meng (2021), and Janthapass et al. (2024) advocate for decentralized curriculum management and multi-modal instructional delivery, encompassing case-based learning, asynchronous online instruction, and hands-on technical training.

Furthermore, robust administrative oversight and structured evaluative mechanisms are essential to ensure long-term pedagogical sustainability. Academic leaders play a pivotal role in driving systemic change across all phases of policy implementation (Yadav, 2022; Jafari & Keykha, 2024). By embedding reflective management frameworks—such as the Planning, Implementation, Evaluation, Reflection, and Improvement (PIERI) cycle—vocational institutions can establish continuous feedback loops. These dynamic mechanisms ensure that educators' AI competencies remain iteratively aligned with rapidly evolving technological landscapes and industrial demands (Mahoney & Kiernan, 2024).

Methodology

This study employs a convergent parallel mixed-methods research design to empirically investigate the structural dimensions, indicator frameworks, and actionable development strategies for AI competencies and lifelong learning among vocational teachers in Thailand. The research process systematically integrates quantitative empirical measurement with qualitative expert validation across four distinct sequential phases.

1. Research Design

To capture the complex, multi-faceted nature of teacher competencies and lifelong learning capabilities, a convergent parallel mixed-methods design was chosen. Quantitative data were utilized to establish statistical validity, measure indicator structures, and perform factor extractions. Concurrently, qualitative data provided contextual depth, administrative perspectives, and expert consensus regarding implementation mechanisms. The research was executed across four structured phases:

Phase 1: Qualitative Baseline Exploration — Qualitative baseline analysis through document synthesis and in-depth administrative interviews.

Phase 2: Quantitative Component Verification — Empirical survey implementation and statistical factor structure validation.

Phase 3: Data Triangulation and Synthesis — Integration of qualitative insights and empirical findings to confirm structural domains.

Phase 4: Expert Connoisseurship and Framework Construction — Qualitative focus group connoisseurship to finalize the execution framework.

2. Participants and Sampling Strategies

The target population comprised institutional administrators, teaching personnel, and educational staff within vocational colleges under the Office of the Vocational Education Commission (OVEC), specifically situated in the Eastern Economic Corridor (EEC) region of Thailand.

2.1 Qualitative Sampling (Phase 1)





In Phase 1, a purposive sampling method was employed to select 12 vocational institution administrators. The inclusion criteria required participants to have a minimum of five years of institutional leadership experience and demonstrated involvement in educational technology or ICT management policies.

2.2 Quantitative Sampling (Phase 2)

In Phase 2, a multi-stage random sampling approach was utilized to select a representative quantitative sample from six vocational colleges across the eastern region.

(1) Stratification: Vocational institutions were stratified by institutional size and specialized curriculum offerings (Engineering, Business Administration, Information Technology).

(2) Cluster Sampling: Six institutions were selected as primary clusters.

(3) Random Selection: A total of 504 valid respondents—comprising administrators, vocational teachers, and academic support staff—were randomly sampled to complete the empirical survey instrument.

2.3 Expert Panel Sampling (Phase 4)

For the connoisseurship phase, a purposive sample of 9 experts was assembled for a Focus Group Discussion. The panel consisted of:

(1) Vocational Education Policy Experts ($n = 3$)

(2) Educational Technology and AI Specialists ($n = 3$)

(3) Senior Vocational College Directors ($n = 3$)

3. Data Collection and Research Instruments

Three primary research instruments were developed, validated, and administered across the research phases as shown in Table 1:

Table 1: Research Instruments, Target Participants, and Purposes Across Research Phases

Phase	Instrument Type	Target Source	Purpose
Phase 1	Semi-Structured Interview Form	12 Administrators	Explore baseline characteristics, institutional needs, and policy gaps
Phase 2	5 - Point Likert Scale Survey	504 Respondents	Quantify 174 indicators across Cognitive, Psychomotor, and Affective domains.
Phase 3 & 4	Focus Group Discussion Protocol	9 Experts	Evaluate, refine, and certify the PIERI strategy framework

Instrument Development and Quality Control

To ensure the validity, reliability, and scientific rigor of the research instruments, a structured multi-stage development and quality assessment process was conducted:

Content Validity: The qualitative semi-structured interview form and the quantitative 5-point Likert scale questionnaire (174 indicators) were evaluated by a panel of five experts in educational technology, vocational administration, and research measurement. The Index of Item-Objective Congruence (IOC) was calculated for each item. All retained items yielded an $\text{IOC} \geq 0.80$, with an overall average IOC score of 0.886, demonstrating high content validity.

Reliability and Discrimination Testing: The quantitative questionnaire was pilot-tested with a try-out sample of 30 vocational institution personnel who shared characteristics similar to the target population but were excluded from the final study sample. Item discrimination was verified using Item-Total Correlation. Internal consistency reliability was evaluated using Cronbach's alpha (α), yielding an overall scale reliability of $\alpha = 0.940$ (with sub-scale reliabilities ranging between 0.880 and 0.950), indicating high internal consistency for data collection.

Validation of Structural Components: Construct validity across the main dimensions (Cognitive, Psychomotor, and Affective domains) was empirically validated using Exploratory Factor Analysis (EFA) with Principal Component Analysis (PCA) and Promax oblique rotation, supplemented by qualitative data triangulation.

4. Research Procedure and Data Analysis





Data were systematically processed using both inferential statistical techniques and thematic qualitative methods.

4.1 Quantitative Data Analysis

Quantitative data collected in Phase 2 were analyzed using statistical software:

(1) Descriptive Statistics: Mean ($\bar{x}$) and Standard Deviation (S.D.) were calculated to assess the level of practice and importance for each item indicator.

(2) Exploratory Factor Analysis (EFA): EFA was conducted to extract the underlying factor structure of AI competencies and lifelong learning constructs.

Sampling Adequacy: The Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test of Sphericity were calculated to confirm data suitability for factor extraction.

Factor Extraction: Principal Component Analysis (PCA) with Promax orthogonal rotation was applied. Items with factor loadings < 0.50 were suppressed.

Variance Explained: Factors were retained based on eigenvalues > 1.0 and cumulative variance explained thresholds.

4.2 Qualitative Data Analysis

Qualitative data from Phase 1 (interviews) and Phase 4 (focus group) were analyzed using Narrative Content Analysis and Thematic Coding. Data were transcribed verbatim, categorized into initial codes, and synthesized into thematic domains corresponding to administrative strategies and operational frameworks.

This study employed a convergent parallel mixed-methods design executed across four phases. Phase 1 involved document synthesis and in-depth interviews with 12 vocational administrators to establish qualitative baseline characteristics. Phase 2 collected quantitative survey data from 504 vocational personnel in the EEC to validate the structural construct of 174 indicators using EFA. Phase 3 integrated qualitative insights with quantitative findings to confirm the core structural components of AI competencies. Finally, Phase 4 utilized expert focus group connoisseurship with 9 educational experts to evaluate, refine, and validate the operational PIERI strategy framework for practical implementation.

Results

The research findings are structured and presented in accordance with the three main research objectives: (1) to examine the key characteristic domains of AI competencies and lifelong learning among vocational teachers; (2) to empirically validate the structural components and indicator frameworks of teacher AI competencies using Exploratory Factor Analysis (EFA); and (3) to construct an actionable operational guidelines and execution framework (PIERI Model) for faculty professional development.

Part 1: Characteristics of AI Competencies and Lifelong Learning for Vocational Teachers (Objective 1)

By triangulating qualitative data from baseline document analysis and in-depth interviews with administrators ($n = 12$), four fundamental characteristic domains defining AI-competent vocational teachers in the digital era were identified. These domains established the qualitative foundation for subsequent indicator generation and structural modeling. Table 2 outlines the identified domains, along with their operational definitions and key behavioral indicators.

Table 2: Qualitative Domains and Key Characteristics of Teacher AI Competencies and Lifelong Learning

Characteristic Domain	Operational Definition	Core Behavioral Indicators
1. AI Literacy Leading to Lifelong Learning	The foundational awareness, legal knowledge, and ethical literacy required to engage with AI technologies continuously and responsibly.	• Demonstrates ethical awareness regarding AI ethics and data privacy. • Identifies appropriate AI tools for personal and professional continuous learning.





		• Evaluates legal implications and copyright issues in AI utilization.
2. AI Skill / Lifelong Learning Ability	The technical proficiency and operational fluency in applying digital tools and generative AI in teaching and technical workflows.	• Utilizes AI platforms for adaptive instructional design. • Operates digital tools to streamline technical curriculum execution. • Engages in self-directed upskilling using emerging educational technologies.
3. Critical Thinking and Problem Solving with AI Tools	The cognitive capacity to critically evaluate AI-generated outputs, solve pedagogical problems, and make data-driven decisions.	• Analyzes the accuracy and bias of AI-generated educational content. • Employs AI tools to solve complex technical and instructional challenges. • Synthesizes data from multiple AI sources to enhance problem-solving.
4. Adaptive AI Transform to Lifelong Learning	The behavioral adaptiveness to technological evolution, fostering collaboration and institutional transformation.	• Adapts instructional strategies to shifting Industry 4.0/5.0 demands. • Collaborates in professional learning communities via AI-enabled platforms. • Leads digital innovation within technical and vocational education contexts.

Part 2: Empirical Structural Components and Indicator Validation (Objective 2)

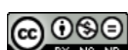
To examine and validate the quantitative factor structure of the 174 identified indicators, survey responses from 504 vocational college personnel ($N = 504$) were analyzed via Exploratory Factor Analysis (EFA) using Principal Component Analysis (PCA) with Promax oblique rotation. Preliminary statistical tests confirmed sampling adequacy and data factorability:

- Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy: 0.953 (exceeding the recommended threshold of 0.60).
- Bartlett's Test of Sphericity: $\chi^2 = 31841.85$, $df = 15051$, $p < .001$ confirming significant correlations among variables.

The empirical factor extraction confirmed that the 174 indicators are structured across 3 Main Domains (Cognitive, Psychomotor, and Affective) encompassing 7 Shared Sub-components. Collectively, the structural framework accounts for 82.50% of the total cumulative variance explained.

Table 3: Exploratory Factor Analysis (EFA) Summary for Main Domains and Sub-Components ($N = 504$)

Domain / Sub-Component	No. of Items	Eigenvalue Range	Variance Explained (%)	Factor Loadings Range
1. Cognitive Domain (Knowledge)	61	8.10 – 18.61	82.01%	0.528 – 0.892
1.1 Computer and AI Fundamentals	9	18.61	21.34%	0.612 – 0.884
1.2 AI Access	8	15.20	14.12%	0.589 – 0.850





1.3 AI Use	9	12.89	12.02%	0.540 – 0.821
1.4 AI Media Production & Creation	9	10.45	10.84%	0.528 – 0.811
1.5 AI Communication	8	9.78	8.92%	0.575 – 0.845
1.6 AI Media Management	9	8.91	7.89%	0.601 – 0.870
1.7 AI Evaluation	9	8.10	6.88%	0.630 – 0.892
2. Psychomotor Domain (Skills)	61	8.14 – 19.14	83.14%	0.515 – 0.904
2.1 Computer and AI Fundamentals	9	19.14	22.10%	0.640 – 0.895
2.2 AI Access	8	15.89	14.85%	0.580 – 0.872
2.3 AI Use	9	13.12	12.41%	0.515 – 0.830
2.4 AI Media Production & Creation	9	11.02	11.01%	0.550 – 0.860
2.5 AI Communication	8	9.94	8.99%	0.602 – 0.881
2.6 AI Media Management	9	8.87	7.21%	0.590 – 0.875
2.7 AI Evaluation	9	8.145	6.57%	0.625 – 0.904
3. Affective Domain (Attitude/Awareness)	52	8.32 – 20.0	82.36%	0.542 – 0.888
3.1 Computer and AI Fundamentals	8	20.01	23.01%	0.650 – 0.888
3.2 AI Access	7	16.11	14.92%	0.595 – 0.861
3.3 AI Use	8	13.5	12.18%	0.542 – 0.825
3.4 AI Media Production & Creation	7	10.89	10.45%	0.560 – 0.840
3.5 AI Communication	7	9.81	8.41%	0.588 – 0.852
3.6 AI Media Management	7	8.95	7.01%	0.610 – 0.870
3.7 AI Evaluation	8	8.32	6.38%	0.620 – 0.880
Total Cumulative Framework	174	—	82.50%	0.515 – 0.904

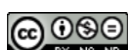
Part 3: Development Strategies and Operational Framework (Objective 3)

Synthesizing the empirical factor structures and qualitative insights from expert connoisseurship ($n = 9$), the study constructed an action-oriented execution framework. The framework operationalizes teacher competency development by integrating five distinct delivery modalities (methods) into the continuous PIERI management cycle (process).

Table 4 details the operational matrix, illustrating how each PIERI phase aligns with execution strategies, delivery modalities, and performance evaluation indicators.

Table 4: Operational Matrix of the PIERI Execution Framework for Vocational Teacher AI Competency Development

PIERI Phase	Core Operational Objective	Execution Strategy & Delivery Modality	Actionable Evaluation Criteria
P–Planning	Institutional alignment and competency benchmarking.	- Conduct institutional AI readiness audit. - Align goals with TVQF and EEC industrial needs.	- Establishment of annual college AI roadmap. - Baseline competency profiles for 100% of teaching staff.





		• Modalities: Self-Directed Learning & Online Diagnostics.	
I–Implementation	Multi-modal capability building and practical execution.	• Execute tiered training (Basic, Intermediate, Advanced). • Deploy hands-on micro-credentials. • Modalities: Case Studies, Practical Workshops, AI-Assisted Learning.	• Teacher completion rate of practical AI workshops ($\geq 85\%$). • Integration of AI tools in active lesson plans.
E–Evaluation	Authentic performance measurement and classroom observation.	• Measure domain scores across Cognitive, Psychomotor, and Affective indicators. • Evaluate AI-generated learning materials. • Modalities: Practical Evaluation & Peer Assessment.	• Minimum score of 80% on functional AI skill rubrics. • Documented improvement in student engagement metrics.
R–Reflection	Peer review, gap identification, and knowledge sharing.	• Conduct Professional Learning Community (PLC) review sessions. • Analyze instructional bottlenecks and AI tool limitations. • Modalities: Reflective Seminars & Case Study Reviews.	• Published portfolio of instructional case studies. • Documented peer feedback loops across departments.
I–Improvement	Iterative curriculum refinement and continuous upskilling.	• Update training modules based on emerging AI capabilities. • Establish industry-linked AI innovation sandboxes. • Modalities: Continuous Online Upskilling & Advanced Seminars.	• Annual revision of AI competency frameworks. • Expansion of industry co-funded WIL programs.

The empirical analysis reveals that the framework for AI competencies and lifelong learning among vocational teachers comprises 3 primary domains, 7 sub-components, and 174 indicators, accounting for 82.50% of the total cumulative variance. By domain, the Cognitive Domain explains 82.01% of the variance, the Psychomotor Domain explains 83.14%, and the Affective Domain explains 82.363%. These encompass seven core sub-components: Computer and AI Fundamentals, AI Access, AI Use, AI Media Production and Creation, AI Communication, AI Media Management, and AI Evaluation.

Competency development is delivered across five modalities: self-directed learning, online learning, case study analysis, AI-assisted learning, and practical training. This framework is operationalized via the five-stage PIERI process comprising Planning, Implementation, Evaluation, Reflection, and Improvement. Key success factors driving implementation include structured curricula, adequate resourcing, well-defined evaluation criteria, systematic monitoring, and robust professional network building.

Conclusion

This study empirically validates a comprehensive structural framework for Artificial Intelligence (AI) competencies and lifelong learning capabilities among vocational education teachers in Thailand. Driven by the urgent need to align faculty capabilities with Industry 4.0 demands and regional economic initiatives in the Eastern Economic Corridor (EEC), the research successfully addressed its core objectives through a rigorous, four-phase convergent parallel mixed-methods design. By systematically integrating qualitative administrative insights ($n = 12$), large-scale quantitative survey verification ($N = 504$), and expert panel connoisseurship ($n = 9$), the study bridges critical empirical gaps in technical and vocational education and training (TVET) literature.





Methodologically, the empirical factor extraction confirmed that teacher AI competency is a robust, tri-domain construct comprising Cognitive (Knowledge), Psychomotor (Skills), and Affective (Attitude/Awareness) dimensions. Exploratory Factor Analysis (EFA) demonstrated exceptional statistical power and construct validity ($KMO = 0.953$, $p < .001$), with the overall framework explaining 82.50% of the total cumulative variance across 7 shared sub-components and 174 indicators. Notably, the high variance explained in the Psychomotor domain (83.14%) highlights that effective AI integration in vocational settings relies heavily on hands-on operational fluency, digital media creation, and technical execution rather than abstract theoretical knowledge.

Beyond structural identification, this study operationalized these empirical dimensions into an actionable execution framework—the expert-validated PIERI Model (Planning, Implementation, Evaluation, Reflection, and Improvement). Delivered across five multi-modal learning formats (self-directed learning, online diagnostics, case studies, AI-assisted learning, and practical workshops), the PIERI cycle shifts faculty professional development from static, one-off training events into a dynamic, closed-loop system of continuous improvement. Ultimately, these findings demonstrate that fostering teacher AI readiness requires a systematic, institutionalized commitment to lifelong learning and organizational adaptability. The validated indicators and operational mechanisms derived from this research provide an evidence-based roadmap to support the national implementation of Thailand's National Vocational Qualifications Framework (TVQF B.E. 2567). Furthermore, by establishing the EEC as an empirical benchmark, this research offers a transferable strategic model for emerging technical economies across Southeast Asia navigating similar digital transformation pressures.

Discussion

The empirical findings of this study provide significant insights into teacher development, educational management, and digital transformation in technical and vocational education. The discussion is structured around three main empirical themes:

1. Structural Dimensions and High Variance Explanation of AI Competencies

The extraction of three main domains explaining 82.50% of total variance (Cognitive: 82.01%, Psychomotor: 83.14%, and Affective: 82.36%) confirms that teacher AI competency is a highly structured, multi-dimensional construct. This aligns with Holmes et al. (2022) and Pansuwong et al. (2023), who argued that effective AI integration in teaching requires a holistic combination of technical understanding, practical application, and ethical awareness. The high variance explained in the Psychomotor domain (83.14%) reinforces the assertion by Arias et al. (2025) that vocational education requires hands-on, operational fluency in emerging media and technological tools rather than purely theoretical knowledge. Furthermore, the identification of the 7 shared sub-components (Computer/AI Fundamentals, Access, Use, Media Production, Communication, Media Management, and Evaluation) expands upon the competency framework proposed by Tang et al. (2025). The inclusion of AI Evaluation as a distinct sub-component supports the findings of Marengo et al. (2024), emphasizing that educators must possess critical evaluation skills to verify AI-generated outputs, address algorithmic bias, and ensure pedagogical integrity.

2. Lifelong Learning as an Imperative for Vocational Teachers in Economic Zones

The qualitative and quantitative findings strongly connect teacher AI literacy with lifelong learning adaptability. In the context of Thailand's EEC, where industry requirements dynamically evolve toward First S-Curve and New S-Curve technologies (Office of the National Economic and Social Development Board, 2017), teachers must act as continuous learners. This outcome corroborates Knight et al. (2023), who posited that self-directed upskilling and adaptiveness are foundational to modern technical professionalism. By embedding lifelong learning within the National Vocational Qualifications Framework (TVQF B.E. 2567) (Office of the Vocational Education Commission, 2017; Janthapass et al., 2024), this study demonstrates that institutional policies must provide structured support for teachers to engage in continuous upskilling. As Zhao and Ko (2024) and Riyanto et al. (2025) noted, institutional sustainability amidst educational disruption depends on aligning faculty capabilities with dynamic industry expectations.

3. Operationalization via the PIERI Framework and Strategic Management





The expert-validated PIERI strategy (Planning, Implementation, Evaluation, Reflection, Improvement) addresses a critical gap in educational management literature: the transition from static competency frameworks to continuous operational execution. Traditional teacher training often relies on isolated, one-off workshops that yield limited long-term impact. The PIERI framework echoes the administrative models advocated by Sinlarat (2020), Ahmed et al. (2023), Namdech et al. (2025), and Mambile and Mwogosi (2025), which stress iterative, closed-loop management systems. Specifically, integrating the PIERI process with 5 delivery modalities (self-directed, online, case studies, AI-assisted, and practical training) offers the flexibility required for adult learners. This multi-modal approach aligns with Lee and Meng (2021), Namdech et al. (2025), and Pham Xuan and Håkansson Lindqvist (2025), who highlighted that digital capacity building is most effective when personalized, reflective, and embedded within collaborative professional learning communities.

To contextualize the empirical findings beyond localized metrics, this section critically interprets the results through broader international frameworks. By re-conceptualizing teacher AI readiness within Industry 4.0 Education, contrasting psychomotor competencies in the Eastern Economic Corridor (EEC) with global high-tech benchmarks, and framing the EEC as an empirical paradigm for emerging technical economies, this discussion transforms regional data into globally meaningful scholarship. The following subsections unpack these theoretical, comparative, and policy dimensions to address critical gaps in TVET research.

1. Re-conceptualizing AI Competencies through the Lens of Industry 4.0 Education

The empirical quantitative findings confirming a three-domain structure (Cognitive, Psychomotor, Affective) and seven sub-components explaining 82.50% of the total cumulative variance demonstrate that AI competency among vocational teachers in the EEC is not merely a collection of isolated technical skills. Rather, it constitutes a comprehensive, competency-based educational ecosystem. This aligns directly with the core tenets of Industry 4.0 Education, which emphasize the seamless integration of cyber-physical systems with human capital development. When examining the Cognitive Domain (explaining 82.01% of variance), the high factor loadings for indicators related to AI Evaluation and AI Media Management indicate that elevating educational paradigms requires moving beyond being mere “AI users” to becoming “Critical AI Evaluators”. This directly resonates with the lifelong learning framework proposed by Janthapass et al. (2024), who argue that modern education must shift from traditional modalities to a decentralized, “anywhere, anytime” landscape. Within this context, educators must possess algorithmic comprehension, maintain acute awareness of data and algorithmic bias, and ethically curate AI-driven media.

2. Psychomotor Competencies in EEC vs. Global High-Tech Hubs: A Comparative Critique

A particularly striking finding is that the Psychomotor Domain accounted for the highest proportion of variance among all three dimensions (83.14%), propelled primarily by sub-components such as AI Media Production & Creation and AI Use. In the context of Thai TVET, this reflects the essential demand for hands-on, operational fluency within technical pedagogical workflows. Comparing the empirical evidence from the EEC with established competency frameworks in global high-tech hubs across Europe (e.g., the DigCompEdu framework) and North America reveals both structural parallels and contextual gaps:

Parallels: Vocational educators in both the EEC and advanced economies require operational proficiency in creating AI-integrated instructional media and interacting with digital platforms to facilitate Work-Integrated Learning (WIL).

Contextual Gaps: While psychomotor expectations in high-tech hubs often emphasize advanced capabilities—such as managing digital twins, executing API integrations, and deploying AI-driven industrial robotics—psychomotor competencies among EEC vocational teachers remain heavily concentrated in Computer/AI Fundamentals (22.10% of variance) and basic AI Access/Use. This divergence illustrates that educators in transitional regions face a distinct “duality of AI integration” (Namdech et al., 2025), wherein they must build foundational digital literacy while simultaneously striving to keep pace with rapid industrial digitization.

3. The EEC as a Benchmark for “Emerging Technical Economies”





This study transcends localized descriptive research by positioning the Eastern Economic Corridor (EEC) as a primary case study for “Emerging Technical Economies.” These economies represent transitional regions rapidly modernizing their industrial infrastructures toward First S-Curve and New S-Curve sectors while struggling with acute workforce skills gaps and institutional resource constraints. The empirical findings underscore that developing teacher competencies within emerging technical economies cannot rely on passive, top-down training. Instead, it requires an active, closed-loop operational mechanism such as the PIERI Framework:

Policy Redesign: This study argues that national frameworks (such as the TVQF B.E. 2567) must evolve from static qualification standards into dynamic, iterative policy mechanisms that embed the PIERI management cycle into continuous professional development.

Mitigating Digital Inequity: Deploying the PIERI model across multi-modal delivery pathways (e.g., self-directed, case-based, and AI-assisted modalities) directly addresses institutional disparities across vocational colleges in the EEC, enabling personalized capacity-building tailored to institutional realities.

In summary, the empirical lessons from Thailand’s EEC provide a transferable empirical blueprint for TVET systems across Southeast Asia and broader developing nations navigating similar digital transformation pressures.

Knowledge Contribution

This study advances the academic understanding of teacher professional development, educational management, and digital transformation in vocational education by establishing a robust, empirically validated framework. The unique theoretical, methodological, and practical contributions of this research are structured into four key dimensions.

1. Theoretical Contribution: Integration of AI Competencies with Lifelong Learning

While existing literature often treats technological skill acquisition and continuous professional adaptability as separate domains, this study establishes a novel theoretical linkage combining AI competencies with lifelong learning capabilities.

1) Holistic Tri-Domain Construct: The findings theoretically prove that AI readiness is not merely a technical skill set, but a multi-dimensional construct spanning Cognitive (Knowledge), Psychomotor (Skills), and Affective (Attitudes/Awareness) domains.

2) Expanded Sub-component Taxonomy: By establishing 7 core sub-components—Computer/AI Fundamentals, Access, Use, Media Production, Communication, Media Management, and Evaluation—the research refines current educational technology theories. Notably, positioning AI Evaluation as a standalone sub-component highlights critical thinking, bias assessment, and pedagogical integrity as indispensable elements of modern educator competence.

2. Methodological Contribution: High-Precision Empirical Measurement Model

Methodologically, this study addresses the scarcity of rigorously validated quantitative instruments designed specifically for technical and vocational educators in developing economies.

1) Comprehensive Indicator Scale: The development and validation of a 174-indicator framework provide future researchers with a standardized, high-precision measurement scale.

2) Empirical Rigor and Statistical Power: Through Exploratory Factor Analysis (EFA), the framework achieved an exceptionally high cumulative variance explained of 82.50% (KMO = 0.953). This provides a benchmark for future SEM and CFA studies examining digital transformation in technical education.

3. Managerial and Operational Contribution: The PIERI Execution Model

A significant gap in educational leadership literature is the disconnect between theoretical competency frameworks and real-world administrative implementation. This study bridges that gap through the expert-validated PIERI Strategy Framework.

1) Closed-Loop Execution System: Moving beyond traditional, static one-off training workshops, the PIERI cycle (Planning, Implementation, Evaluation, Reflection, Improvement) offers educational administrators a continuous, iterative management mechanism.





2) Multi-Modal Personalization: By pairing the 5-stage PIERI process with 5 flexible learning modalities (self-directed, online, case-based, AI-assisted, and practical training), the framework provides a practical roadmap for creating reflective, peer-supported Professional Learning Communities (PLCs) within vocational institutions.

4. Contextual and Policy Contribution: Evidence for Emerging Technical Economies

The findings offer significant context-specific value for national educational policy and regional economic strategies in developing and transitional economies.

1) Alignment with TVQF B.E. 2567: The framework directly supports Thailand's National Vocational Qualifications Framework, offering measurable indicators for teacher evaluation and qualification benchmarking.

2) Strategic Economic Relevance: By generating empirical evidence from vocational colleges in the EEC area, the study demonstrates how teacher competency frameworks can be aligned directly with high-tech industry demands (S-Curve industries), serving as a benchmark model for technical education systems across Southeast Asia and similar emerging economies.

Recommendations

Based on the empirical findings, structural factor validations, and the expert-certified PIERI framework, this study proposes actionable recommendations categorized into three main levels: policy recommendations, institutional/operational recommendations, and directions for future research.

1. Recommendations for Educational Policy (National & Regional Levels)

1.1 Alignment with National Qualifications Framework (TVQF B.E. 2567): The Office of the Vocational Education Commission (OVEC) and relevant policymakers should formally integrate the 7 sub-components (Computer/AI Fundamentals, Access, Use, Media Production, Communication, Media Management, and Evaluation) into the teacher competency evaluation criteria under the National Vocational Qualifications Framework. This will establish standardized benchmarks for instructor licensing, professional development, and career advancement.

1.2 Strategic Resource Allocation for Technical Economic Zones (EEC): Government agencies should allocate targeted funding and digital infrastructure grants—such as high-speed networks, enterprise AI software licenses, and dedicated AI data services—to vocational colleges located in strategic economic zones like the Eastern Economic Corridor (EEC). Ensuring equitable technological access will enable instructors to align their curriculum directly with First S-Curve and New S-Curve industrial demands.

1.3 Policy Support for Innovation Sandboxes: Policymakers should establish regulatory framework sandboxes that allow vocational colleges to experiment with AI-driven pedagogical tools, Work-Integrated Learning (WIL) models, and micro-credential certifications without restrictive traditional administrative burdens.

2. Recommendations for Institutional Practice and Management (College Level)

2.1 Implementation of the PIERI Continuous Management Cycle: Vocational college administrators should replace traditional, one-off training workshops with the closed-loop PIERI Framework (Planning, Implementation, Evaluation, Reflection, Improvement). Institutional leadership should embed this cycle into annual institutional action plans and individual teacher development plans (ID Plans).

2.2 Deployment of Multi-Modal Professional Development: Academic administrators should offer flexible, tiered professional development opportunities across the 5 validated delivery modalities:

- 1) Self-Directed Learning: Providing curated online AI learning pathways.
- 2) Online & Case-Based Modules: Analyzing real-world classroom technology integration.
- 3) AI-Assisted Learning: Utilizing generative AI tools for automated lesson planning and assessment design.
- 4) Practical Workshops: Facilitating hands-on skill development in media creation and critical AI output evaluation.





2.3 Fostering Professional Learning Communities (PLCs) & Mentorship: Colleges should establish peer-supported PLCs specifically focused on AI media management and evaluation. Experienced, tech-empowered teachers should mentor peers to accelerate digital adaptation and share best practices in a collaborative environment.

3. Recommendations for Future Research

3.1 Expansion of Geographical Sample Scope:

Because this study focused primarily on vocational colleges within the Eastern Economic Corridor (EEC) of Thailand, future research should expand sample collection nationwide to include diverse geographical regions, evaluating cross-regional model consistency and institutional disparities.

3.2 Advanced Structural Modeling (CFA & SEM):

Future quantitative studies should employ Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) to test the causal relationships, structural fit, and predictive validity between teacher AI competencies, institutional support, and student technical learning outcomes.

3.3 Longitudinal and Impact Assessment Studies:

Researchers should conduct longitudinal studies tracking the multi-year implementation of the PIERI framework. Evaluating the long-term impact of teacher AI upskilling on graduate employability, workforce readiness, and classroom engagement will provide deeper insights for sustainable educational reform.

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Conflicts of Interest

The authors declare that they have no competing interests or financial conflicts of interest that could inappropriately influence or bias the content, research findings, or reporting of this manuscript.

Data Availability Statement

The quantitative survey data ($N = 504$) and qualitative interview/focus group transcripts generated and analyzed during the current study are available from the corresponding author upon reasonable request, subject to institutional ethical privacy constraints.

Ethics Approval and Consent to Participate

This study was conducted in accordance with the ethical principles for research involving human participants. Institutional approval and ethical oversight were obtained before data collection. Informed consent was obtained from all individual participants (administrators, vocational teachers, educational staff, and expert panelists) before they participated in the interviews, survey administration, and focus group discussions. All participant data were anonymized to ensure privacy and confidentiality.

Generative AI Disclosure

The authors confirm that no generative Artificial Intelligence (AI) technologies or Large Language Models (LLMs) were used in the conception, data collection, statistical analysis (EFA), or drawing of empirical conclusions for this study. Generative AI tools were utilized solely as writing assistance to aid in language polishing, grammar verification, and improving text readability during the manuscript preparation phase. The authors reviewed, edited, and take full responsibility for the final content of the manuscript.

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