# The STUDIES model: validating a human-centric framework for Education 5.0

**Phichittra Thongpanit[1], Pratya Thongpanit[2], Sutep Uamcharoen[3]**
[1]Faculty of Education, Nakhon Phanom University, Nakhon Phanom, Thailand
[2]Faculty of Science, Nakhon Phanom University, Nakhon Phanom, Thailand
[3]School of Education, Walailak University, Nakhon Si Thammarat, Thailand

**Article Info**

***Article history:***

Received Mar 22, 2026
Revised Aug 3, 2026
Accepted Aug 14, 2026

***Keywords:***

Digital humanism
Education 5.0
Human-centric
Metacognition
Pre-service teachers
STUDIES model

**ABSTRACT**

This study addresses the gap in teacher education frameworks that integrate Education 5.0 principles with empirically validated metacognitive development. The purpose was to develop and validate a seven-stage human-centric instructional framework, the setting goals, task analysis, universal design, digital learning, integrated knowledge, evaluation, standards-based assessment (STUDIES) model, grounded in constructivism, self-determination theory, and digital humanism, and to evaluate its effectiveness across three sequential phases with pre-service teachers. Three published phases employed one-group pretest–posttest designs. Phase I ($N=24$, English education) achieved efficiency ratios E1/E2 of 80.56/80.68 ($t(23)=26.17$, $p<.01$, Cohen's $d=4.69$); Phase II ($N=28$, early childhood) achieved E1/E2=80.95/81.36 ($t(27)=-54.77$, $p<.001$, $d=6.17$); Phase III ($N=30$, mathematics with phenomenon-based learning and a digital learning ecosystem) achieved 80.25% post-test metacognition (normalized gain=0.64, $t(29)=-36.37$, $p<.001$, $d=3.08$). The novel contribution is its empirically validated progressive trajectory—from knowledge acquisition through higher-order thinking to metacognitive mastery—which mirrors a recognized hierarchical taxonomy and has not been demonstrated in existing Education 5.0 frameworks. Implications are discussed for teacher education policy, curriculum reform, and scalable program design.



***Corresponding Author:***

Pratya Thongpanit
Faculty of Science, Nakhon Phanom University
214 Moo 12, Nittayo Road, Nong Yat Subdistrict, Mueang District, Nakhon Phanom-48000, Thailand
Email: p.thongpanit@npu.ac.th

## 1. INTRODUCTION

The transition from Industry 4.0 to Society 5.0—a super-smart society prioritizing human well-being alongside technological advancement [1]—has created an urgent imperative for transforming teacher education worldwide. Education 5.0 embraces digital humanism, emphasizing holistic learner development across cognitive, emotional, social, and ethical dimensions while leveraging technology responsibly [2], [3]. This paradigm positions artificial intelligence (AI) not as a replacement for human agency but as a cognitive partner that empowers teachers and learners to cultivate uniquely human competencies, including empathy, ethical reasoning, and creative problem-solving.

Within the Thai educational context, this transformation carries particular urgency for both policy and practice. Thailand's Programme for International Student Assessment (PISA) 2022 results revealed an average science score of 409 points, significantly below the Organization for Economic Co-operation and Development (OECD) average [4], while the 20-year National Strategy (2018–2037) mandates a shift from labor-intensive to innovation-driven economic development [5]. The Teachers' Council of Thailand professional knowledge standards, which explicitly require pre-service teachers to be able to design learning plans and manage classrooms effectively [6], further emphasize the necessity of evidence-based instructional frameworks. As Fry and Bi [7] have documented, however, recurrent cycles of educational reform in Thailand have often failed to translate policy intentions into classroom-level competency gains, creating what they term the "Thai educational paradox" that the present framework is explicitly designed to address.

Despite the growing scholarly interest in Education 5.0 [1], [8], the operationalization of this paradigm in teacher education programs remains poorly developed, and a focused review of recent literature reveals three critical limitations that motivate the present study. First, most Education 5.0 models remain at the conceptual level without empirical validation in classroom settings [1], [9]. Second, traditional pedagogical models—including science, technology, engineering, and mathematics (STEM)-focused approaches [10] and competency-based frameworks [11]—lack integration of self-determination theory (SDT) mechanisms that foster intrinsic motivation and sustained professional learning [12]. Third, although metacognition is widely recognized as essential for self-regulated learning [13], [14], no existing Education 5.0 framework provides a systematic pathway for developing metacognitive mastery through progressive, empirically validated phases.

The setting goals, task analysis, universal design, digital learning, integrated knowledge, evaluation, standards-based assessment (STUDIES) model: Education 5.0 [15] was developed to address these gaps by integrating constructivist theory [16], SDT [17], [18], universal design for instruction [19], Marzano and Kendall's [20] New Taxonomy, and phenomenon-based learning [21] within a coherent seven-stage framework. Unlike existing Education 5.0 models, the STUDIES model has been progressively validated across three published phases, demonstrating effectiveness in developing increasingly sophisticated cognitive capabilities—from foundational knowledge through higher-order thinking skills (HOTS) to metacognitive mastery, a trajectory that has not been empirically demonstrated by any other framework in this domain.

To systematically examine this framework, this study addresses three research questions that progress from theoretical alignment to empirical effectiveness and explanatory mechanisms.

- RQ1: In what ways does the seven-stage STUDIES model fit with the five pillars of Education 5.0?
- RQ2: To what extent does the model produce significant improvements in knowledge, higher-order thinking, and metacognition across three validation phases?
- RQ3: What theoretical mechanisms explain the observed progressive development from content mastery to metacognitive awareness?

The novelty of this study lies in three interrelated contributions that distinguish the STUDIES model from existing teacher-education and Education 5.0 frameworks. First, the model offers an empirically validated progressive pathway in which a single seven-stage architecture is shown, across three sequential phases, to develop knowledge, HOTS, and metacognition—a trajectory that mirrors Marzano and Kendall's hierarchical taxonomy [20] and that has not been demonstrated in prior frameworks. Second, the model uniquely synthesizes digital humanism, SDT, universal design, and phenomenon-based learning (PhBL) into a coherent and reusable architecture, with each stage explicitly mapped to one of the five Education 5.0 pillars [2] and to a specific basic psychological need. Third, the cumulative cross-disciplinary validation across English, early childhood, and mathematics teacher education provides preliminary evidence of the generalizability of the framework beyond a single subject area or single intervention.

## 2. LITERATURE REVIEW

This section reviews four converging strands that together define the theoretical foundation of the STUDIES model: Education 5.0, constructivism and SDT, universal design and metacognitive systems, and PhBL within digital ecosystems. Each strand identifies a key contribution to teacher education while exposing limitations that motivate the model's integrative architecture.

### 2.1. Education 5.0 and current frameworks for teacher education

The evolution from Education 1.0 through 5.0 reflects adaptive responses to socioeconomic and technological dynamics [8]. Ahmad *et al.* [2] synthesized five pillars of Education 5.0: learner-centric personalization, collaborative interdisciplinary learning, data-driven decision-making, enabling technologies for cognitive enhancement, and holistic authentic assessment. The European Commission articulation of Industry 5.0 [3] further frames human-centricity, sustainability, and resilience as normative anchors, although Hamedani *et al.* [1] noted that empirical operationalization of these pillars in teacher education remains scarce, particularly in developing-country contexts.

Compared with existing teacher-education frameworks, the STUDIES model offers distinct contributions. STEM-focused models such as the technological pedagogical content knowledge (TPACK) framework [22] address technological pedagogical knowledge but lack explicit SDT-driven engagement mechanisms, while traditional competency-based approaches [11] specify outcomes without addressing the motivational architecture needed for sustained professional learning. The STUDIES model uniquely synthesizes digital literacy, metacognitive advancement, and SDT-driven engagement into a single cohesive architecture aligned with all five pillars of Education 5.0 [2].

### 2.2. Constructivism and self-determination theory

The epistemological foundation of the STUDIES model is based on constructivist learning theory [16] and Vygotsky's zone of proximal development [23], with scaffolding extended in Education 5.0 contexts to AI-powered tutoring systems that provide personalized feedback [24]. SDT [17], [18] provides the motivational architecture, asserting that intrinsic motivation arises from fulfilling autonomy, competence, and relatedness needs; Howard *et al.*'s meta-analysis [12] confirmed that satisfying these three needs is the strongest predictor of deep learning. The collaborative dimensions of the model fulfill the need for relatedness through cooperative learning structures [25], a dimension largely absent from existing Education 5.0 frameworks.

### 2.3. Universal design and metacognitive systems

The model's commitment to equity is anchored in universal design for instruction (UDI) [19] and universal design for learning (UDL) [26], while the cognitive architecture combines Bloom's revised taxonomy [27] with Marzano and Kendall's new taxonomy [20], which adds the metacognitive system and the self-system. Veenman *et al.* [28] demonstrated that metacognitive skills account for approximately 17% of variance in learning outcomes beyond intelligence, and Dignath *et al.* [29] confirmed through meta-analysis that metacognitive training significantly enhances academic performance across educational levels. The finding justify treating metacognition not as an add-on but as the apex of a progressive cognitive trajectory.

### 2.4. Phenomenon-based learning and digital learning ecosystems

PhBL, originating from Finland's educational reforms, transcends fragmented subject-based teaching through integrated real-world learning experiences [21], and when situated within a digital learning ecosystem [30], it creates conditions for the development of metacognitive awareness. Hattie [31] identified metacognitive strategies as one of the highest-impact teaching approaches (d=0.69), while Zheng [32] showed that technology-enhanced environments effectively support metacognitive development when designed with explicit self-regulation scaffolds. Together, these findings justify stage I (integrated transdisciplinary knowledge) and stage D (digital deep learning) within the STUDIES architecture.

## 3. THE STUDIES MODEL: EDUCATION 5.0

The STUDIES model [15] was developed through systematic research and development at Nakhon Phanom University to address competency gaps in pre-service teacher education. The model has been elevated to align with Education 5.0 through the integration of Society 5.0 philosophy, design thinking, SDT, and ethical AI application. The seven stages operate as a dynamic, iterative system, with each stage mapped to a specific Education 5.0 pillar and a specific SDT need as shown in Figure 1.

Figure 1 presents a schematic representation of the seven STUDIES stages, illustrating the iterative relationships among the stages, their alignment with the pillars of Education 5.0, and the primary SDT need addressed by each stage. The forward arrows depict the typical sequence S→T→U→D→I→E→S, while the dashed feedback loop indicates ongoing reflection and continuous improvement.

### 3.1. Stage S: setting visionary learning goals

This stage transcends content-based goals to embrace competency-based outcomes that combine declarative, procedural, and metacognitive knowledge [27]. Goals encompass analytical thinking, creative problem-solving, digital intelligence, and social-emotional resilience aligned with Education 5.0 demands. Aligned with the Education 5.0 pillar of learner-centric personalization, this stage addresses the SDT need for autonomy by involving learners in collaborative goal-setting processes that build ownership over the learning trajectory.

### 3.2. Stage T: task analysis via backward design

This stage synthesizes knowledge, skill, and attitude (KSA) requirements through KSA diagrams [33], enhanced by backward design principles [34] and design thinking's human-centered problem-solving process [35]. The integration ensures authentic, real-world connected learning tasks that build competence (SDT) through progressively challenging activities. The stage avoids content-coverage bias by structuring tasks around end-of-unit competencies first. This makes sure that every activity leads to a measurable learning outcome.

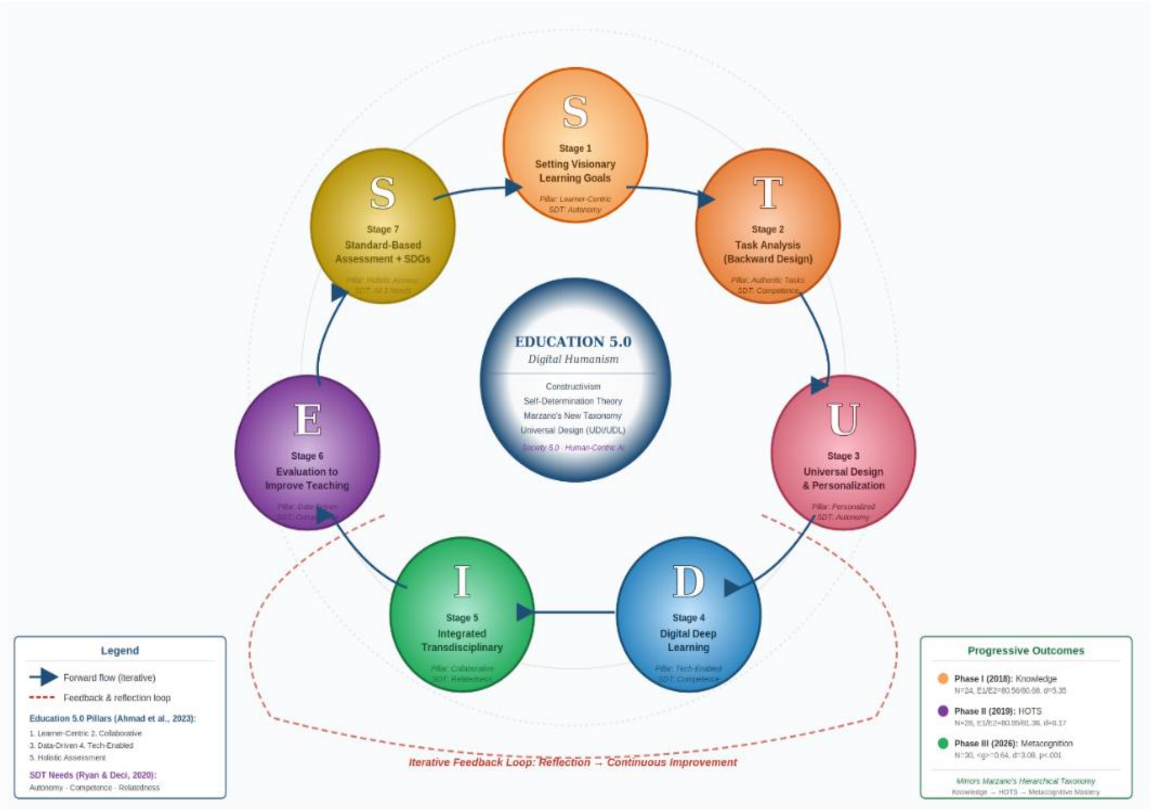


Figure 1. The STUDIES model: Education 5.0—schematic of the seven-stage iterative framework

### 3.3. Stage U: universal design for instruction and personalized learning

This stage emphasizes proactive instructional design that eliminates barriers to learning access [19], enriched by UDL's three-component framework [26] and AI-driven personalization. It operationalizes the SDT need for autonomy by providing genuine learner choices in content engagement, learning pace, and assessment modality. Together, UDI principles and AI-enabled personalization make the stage particularly suited to inclusive Education 5.0 classrooms in which learner diversity is the norm rather than the exception.

### 3.4. Stage D: digital deep learning

Digital learning extends beyond information retrieval to comprehensive learning ecosystems attending to content quality, digital ethics, and reflective practice. Learners become co-creators with generative AI, virtual and augmented reality (VR/AR), learning analytics, and blockchain-based credentialing [2], [24]. Digital learning ecosystem principles [30] create interconnected environments for knowledge sharing and metacognitive development, facilitating collaboration, enhancing critical thinking, and promoting deeper conceptual understanding across disciplines. Through these mechanisms, the stage builds competence (SDT) by developing mastery of digital tools and cultivating digital citizenship.

### 3.5. Stage I: integrated transdisciplinary knowledge

This stage facilitates knowledge integration across disciplinary boundaries [36], elevating it to transdisciplinary integration through science, technology, engineering, arts, and mathematics (STEAM) education and design thinking. Collaborative learning fulfills the SDT need for relatedness through cooperative learning structures [25]. PhBL is particularly powerful at this stage, as it connects theoretical knowledge with real-world contexts [21] and creates authentic motivation for deeper conceptual integration.

### 3.6. Stage E: evaluation to improve teaching

This formative evaluation stage employs both Bloom's revised taxonomy [27] and Marzano's new taxonomy [20], including an assessment of the metacognitive system. Data-driven assessment through learning analytics enables real-time identification of cognitive gaps and timely instructional adjustment [37], complemented by Marzano's [38] research-based instructional strategies for cueing, summarizing, and providing feedback that have shown consistent effect sizes across classroom contexts. The stage builds competence (SDT) by providing specific, actionable feedback that supports continuous learner growth and aligns assessment evidence directly with the goals set in stage S.

### 3.7. Stage S: standard-based assessment and global goals

The summative evaluation employs the structure of observed learning outcomes (SOLO) taxonomy [39] for classifying intellectual depth, benchmarked against national curriculum standards, sustainable development goal 4 [40], and international digital competency frameworks. This stage ensures that program outcomes meet both national accreditation requirements and global quality benchmarks. By closing the assessment loop, the stage links classroom-level evidence with broader institutional and international quality assurance systems, completing the iterative cycle of the model.

### 3.8. Semester implementation example

To illustrate how the seven stages translate into routine classroom practice, Table 1 maps the STUDIES architecture onto a 16-week pre-service teacher-education course on instructional design. Each row of the table specifies the corresponding stage, the recommended weeks, the key activities, the assessment evidence, and a benchmark for the targeted competency. This implementation roadmap is intended to support replication by teacher educators in similar institutional contexts and to facilitate cross-program comparison.

The implementation example is organized around four design principles. First, the stages are sequenced but iterative, meaning that earlier stages are revisited in light of evidence gathered in later ones. Second, every stage produces an artifact that can be assessed against an explicit benchmark, enabling formative monitoring throughout the semester. Third, digital tools are introduced progressively, beginning with established learning platforms and culminating in generative AI co-creation in stage D, while collaborative and individual work alternate so that all three SDT needs are addressed across the course.

Table 1. Semester implementation of STUDIES stages with activities, assessments, and benchmarks

| Stage | Weeks | Key activities | Assessment | Benchmark |
|---|---|---|---|---|
| S (Goals) | 1–2 | The activities include learner profiling, a collaborative goal-setting workshop, and the articulation of competency outcomes. | Reflective goal statement | 90% articulate measurable competency goals |
| T (Task) | 3–4 | Backward design mapping; KSA analysis; authentic task development | Task analysis portfolio | IOC $\geq$ 0.80 by expert panel |
| U (Universal) | 5–6 | UDI/UDL audit; AI-personalized pathway design; accessibility review | Inclusive lesson plan | All plans meet UDI 9 principles |
| D (Digital) | 7–9 | Digital tool exploration; GenAI co-creation; VR/AR prototyping; digital ethics seminar | Digital portfolio | $\geq$ 80% digital literacy rubric |
| I (Integrated) | 10–12 | Transdisciplinary project, STEAM challenge, community phenomenon investigation, cooperative learning [25] | Group project + peer assessment | Creative-generative level |
| E (Evaluation) | 13–14 | Formative assessment design; learning analytics interpretation; metacognitive reflection journals | Assessment rubric + feedback protocol | Metacognitive awareness inventory $\geq$ 80% |
| S (Standards) | 15–16 | SOLO taxonomy mapping; alignment with professional standards [6] and SDG 4; summative portfolio defense | Portfolio defense + standardized test | $E_1/E_2 \geq 80/80$; SOLO extended abstract |

## 4. METHOD

This section reports the research design, participants, instruments, procedures, ethical considerations, and analysis methods for each of the three validation phases. The presentation follows a parallel structure across phases to facilitate comparison while preserving phase-specific details. Table 2 concludes with a phase comparison matrix that consolidates these methodological features.

### 4.1. Research design overview

This study employed a multi-phase validation design across three sequential phases, each using a one-group pretest–posttest design [41]. While this design does not permit causal inference due to the absence of a control group, it is appropriate for initial model validation in which the primary goal is to establish whether an intervention produces meaningful learning gains [41].

### 4.2. Phase I: development and validation (2018)

Phase I focused on the foundational development of the STUDIES model and its initial validation in the context of pre-service English-language teacher education. The phase tested whether the seven-stage architecture could produce knowledge gains and high-quality lesson plans within a 15-week course. The design and procedures established the methodological template for the subsequent two phases.

- Design: one-group pretest–posttest [41].
- Participants: 24 second-year pre-service English education students at Nakhon Phanom University, selected through purposive sampling based on enrollment in the required pedagogical methods course; all participants (100% female, mean age 20.3 years) volunteered and provided informed consent.
- Instruments: i) a 60-item knowledge test (Kuder–Richardson 20 [KR-20]=0.85, item difficulty index 0.30–0.70, discrimination index ≥0.20), validated by five experts using item-objective congruence (IOC=0.80–1.00); ii) a lesson plan evaluation rubric with four performance levels (imitative, reproductive, productive, and creative-generative); and iii) a 5-point Likert-type opinion questionnaire (Cronbach's α=0.89).
- Procedure: a 15-week intervention (45 contact hours) implementing all seven STUDIES stages, with the pre-test administered in week 1 and the post-test plus opinion survey in week 15.
- Analysis: efficiency ratios E1/E2 (process/product) using the 80/80 mastery criterion [42], the effectiveness index (E.I.) [43], and a dependent samples t-test (α=.05).
- Sample size justification: for a one-group pretest–posttest design with an expected large effect (d=0.80), α=0.05, and power=0.80, the minimum required N=15 (G*Power 3.1; [44]); the actual sample (N=24) exceeded this threshold.

### 4.3. Phase II: higher-order thinking skills (2019)

Phase II extended the model to early-childhood teacher education, with a primary focus on the development of HOTS within curriculum design. The phase tested whether the STUDIES architecture could deliver gains beyond declarative knowledge into the analyze, evaluate, and create levels of Bloom's revised taxonomy [27]. Procedures paralleled Phase I to allow cross-phase comparison.

- Design: one-group pretest–posttest [41].
- Participants: 28 second-year early-childhood education students, selected through purposive sampling; all participants (96% female, mean age 20.1 years) provided informed consent. Instruments: i) a 60-item higher-order thinking test (KR-20=0.87, validated by five experts, IOC=0.80–1.00); ii) a curriculum development evaluation rubric; and iii) an opinion questionnaire (Cronbach's α=0.91).
- Procedure: a 15-week intervention (45 hours) implementing the STUDIES-based teaching paradigm for curriculum development, with a pre-test in Week 1 and a post-test in Week 15.
- Analysis: E1/E2 criterion, E.I., and a dependent samples t-test.
- Sample size justification: N=28 exceeded the minimum N=15 required for the same power parameters as Phase I.

### 4.4. Phase III: phenomenon-based learning and metacognition (2026)

Phase III evaluated the model in mathematics teacher education, integrating PhBL and a digital learning ecosystem to target metacognitive development. This phase represents the highest level in the progressive trajectory because metacognition occupies the top of Marzano and Kendall's [20] hierarchy. The procedure was condensed to 12 weeks while preserving the seven-stage logic.

- Design: one-group pretest–posttest [41].
- Participants: 30 second-year pre-service mathematics education students at Nakhon Phanom University, selected through cluster random sampling (one intact class drawn from two available sections); participant characteristics were 63% female with a mean age of 20.5 years, and all provided informed consent.
- Instruments: i) a 60-item metacognition achievement test aligned with Marzano's metacognitive system [20] (KR-20=0.83, IOC=0.67–1.00, validated by three experts); ii) a metacognitive awareness inventory adapted from Schraw and Dennison [14] (Cronbach's α=0.92); and iii) an opinion questionnaire (Cronbach's α=0.88).
- Procedure: a 12-week intervention (36 contact hours) organized in three sub-phases aligned with the STUDIES architecture: i) learning planning (stages S–T, weeks 1–3); ii) transformative learning through digital ecosystem integration and phenomenon-based inquiry (stages U–D–I, weeks 4–9); and iii) learning assessment encompassing the knowledge and metacognitive systems (stages E–S, weeks 10–12).
- Analysis: percentage criterion (80%), Hake's normalized gain [45], and a dependent samples t-test.
- Sample size justification: N=30 exceeded the minimum N=15 derived from the same a priori power analysis.

### 4.5. Ethical considerations

All three phases adhered to the ethical principles of the Declaration of Helsinki and received approval through the institutional review processes at Nakhon Phanom University. Participation was voluntary, informed consent was obtained from all participants prior to data collection, and data were anonymized using numerical codes and stored securely on password-protected institutional servers. Participants were further informed of their right to withdraw at any time without academic penalty, and research procedures were reviewed and approved by the Faculty of Education's ethics committee.

### 4.6. Phase comparison matrix

To provide a transparent overview of the three phases, Table 2 consolidates their methodological features along 12 dimensions. The matrix highlights both the commonalities (shared design, similar sample sizes, comparable instrument quality) and the deliberate progression in target outcomes (knowledge, HOTS, metacognition). This consolidated view supports cross-phase interpretation in the results and discussion sections.

Table 2. Comparison of validation phases: design, participants, instruments, and analysis methods

| Component | Phase I (2018) | Phase II (2019) | Phase III (2026) |
|---|---|---|---|
| Context | English education | Early childhood curriculum | Mathematics+PhBL |
| Design | One-group pretest–posttest | One-group pretest–posttest | One-group pretest–posttest |
| N | 24 | 28 | 30 |
| Sampling | Purposive | Purposive | Cluster random |
| Duration | 15 weeks (45 hrs) | 15 weeks (45 hrs) | 12 weeks (36 hrs) |
| Primary DV | Knowledge | Higher-order thinking | Metacognition |
| Knowledge test KR-20 | 0.85 | 0.87 | 0.83 |
| Opinion α | 0.89 | 0.91 | 0.88 |
| Expert IOC | 0.80–1.00 | 0.80–1.00 | 0.67–1.00 |
| Analysis | $E_1/E_2$, E.I., t-test | $E_1/E_2$, E.I., t-test | %, <g>, t-test |
| Publication status | Published [15] | Published [46] | Published [47] |

## 5. RESULTS

This section reports the empirical findings of the three validation phases in turn, beginning with phase-level effects and concluding with a cross-phase summary. For each phase, the report follows the same order: psychometric quality of instruments, efficiency or gain indicators, inferential test, effect size, and student opinions. The cross-phase comparison in Table 3 then situates these findings within the progressive trajectory anticipated by the model.

Table 3. Summary of key metrics across three validation phases

| Metric | Phase I | Phase II | Phase III |
|---|---|---|---|
| Pre-test M (SD) | 29.67 (5.18) | 29.46 (3.84) | 27.56 (7.28) |
| Post-test M (SD) | 48.41 (2.26) | 48.82 (2.21) | 48.56 (6.35) |
| t-statistic (df) | 26.17 (23) | −54.77 (27) | −36.37 (29) |
| p-value | <.01 | <.001 | <.001 |
| Cohen's d | 4.69 | 6.17 | 3.08 |
| $E_1/E_2$ | 80.56/80.68 | 80.95/81.36 | N/A |
| Effectiveness Index | 0.62 | 0.63 | N/A |
| Normalized gain <g> | N/A | N/A | 0.64 (medium) |
| Expert rating | High (4.28) | High (4.26) | High agreement |
| Primary outcome | Knowledge | HOTS | Metacognition |

Note: Cohen's d is calculated as $(M_{post}–M_{pre})/SD_{pooled}$. The large effect sizes reflect the within-group design; between-group comparisons would likely yield smaller effects. $E_1/E_2$=efficiency ratio based on the 80/80 mastery criterion [42]. <g>=Hake's normalized gain [45].

### 5.1. Phase I results: knowledge acquisition

Expert validation yielded IOC values of 0.80–1.00, confirming the content validity of the knowledge test. Efficiency testing produced $E_1/E_2$=80.56/80.68, meeting the 80/80 mastery criterion [42]. The E.I. was 0.62, indicating that 62% of what participants did not know before instruction was learned during the intervention.

Post-test scores (M=48.41, SD=2.26) were significantly higher than pre-test scores (M=29.67, SD=5.18), t(23)=26.17, p<.01, Cohen's d=4.69. The majority (58.33%) demonstrated creative-generative-level lesson planning, the highest level of the rubric. Expert quality assessment rated the model at a high level

(M=4.28, SD=0.53), and student opinions were positive across all dimensions: learning atmosphere (M=4.38, SD=0.64), activities (M=4.37, SD=0.58), and perceived benefits (M=4.37, SD=0.70).

### 5.2. Phase II results: higher-order thinking

Expert evaluation rated the paradigm at the high level (M=4.26, SD=0.50), and efficiency testing produced $E_1/E_2$=80.95/81.36 with E.I.=0.63. Post-instruction scores (M=48.82, SD=2.21) were significantly higher than pre-instruction scores (M=29.46, SD=3.84), $t(27)=-54.77$, $p<.001$, Cohen's d=6.17. Students demonstrated satisfactory-level curriculum development abilities consistent with the rubric anchors.

Beyond the cognitive outcomes, students reported strong affective endorsement of the paradigm. The highest endorsement was for practical career benefits (M=4.50, SD=0.71) and self-directed higher-order thinking development (M=4.46, SD=0.64). These ratings suggest that the model produced measurable HOTS gains and fostered a sense of professional value that supports sustained engagement.

### 5.3. Phase III results: metacognitive development

Expert validation yielded IOC values of 0.67–1.00 across the metacognition items. The mean percentage score of metacognition achievement reached 80.25%, meeting the established criterion. The class-level normalized gain was medium ($\langle g \rangle$=0.64), indicating substantial learning progression from pre- to post-intervention [45].

Post-test metacognition scores (M=48.56, SD=6.35) were significantly higher than pre-test scores (M=27.56, SD=7.28), $t(29)=-36.37$, $p<.001$, Cohen's d=3.08. Student opinions were at a high agreement level, with the highest endorsement for enhanced digital skills and applicability to future teaching careers. These dual indicators—cognitive gain plus affective endorsement—mirror the pattern observed in Phases I and II at the higher metacognitive level of the trajectory.

### 5.4. Summary of results across phases

Table 3 consolidates the key inferential, descriptive, and effect-size statistics across the three phases. The summary supports a direct cross-phase comparison and complements the within-phase narratives. Three patterns are particularly noteworthy. First, all three phases produced statistically significant pre–post differences ($p<.01$ or $p<.001$), with very large within-group effect sizes (d=3.08–6.17). Second, both efficiency-based criteria ($E_1/E_2$, E.I.) in Phases I–II and gain-based criteria ($\langle g \rangle$) in Phase III met or exceeded conventional thresholds for instructional effectiveness. Third, the magnitude of the effect appropriately attenuates as the target outcome moves from declarative knowledge (Phase I) toward more demanding cognitive systems (HOTS, metacognition), which is consistent with the higher cognitive load of the upper levels of Marzano's taxonomy [20].

## 6. DISCUSSION

This section interprets the findings against the theoretical framework that motivated the model and against the broader empirical literature. The discussion is organized around three perspectives: theoretical mechanisms, comparison with existing evidence, and policy implications. Each perspective addresses one of the three research questions.

### 6.1. Theoretical mechanisms explaining the results

The cumulative findings across three phases illuminate how the constructivist learning cycle operates within the STUDIES model to produce consistent outcomes. Drawing on Gagnon and Collay's [16] framework, the seven stages map onto three recursive phases: clarifying existing knowledge (stages S–T), identifying and understanding new information (stages U–D–I), and confirming and using new knowledge (stages E–S). This recursive structure ensures that learners build on what they already know rather than merely add to it.

The Phase III findings demonstrate that this constructivist architecture can effectively develop metacognition—the highest-order system in Marzano and Kendall's taxonomy [20]. When PhBL links theoretical concepts to authentic real-world contexts [21] and a digital learning ecosystem provides collaborative reflection tools [30], learners inherently engage in the planning, monitoring, and evaluating activities that define metacognitive practice [13], [14]. This finding is consistent with the works [28], [29], who identified metacognition as a significant predictor of learning outcomes, irrespective of intelligence.

The progressive trajectory from knowledge acquisition (Phase I) through HOTS (Phase II) to metacognitive development (Phase III) mirrors the hierarchical structure of Marzano and Kendall's [20] taxonomy. This empirically observed progression validates the theoretical premise that lower-order cognitive competencies serve as necessary foundations for higher-order metacognitive capabilities and represents a unique contribution of the STUDIES model. This pattern parallels Chi and Wylie's [48] interactive–constructive–active–passive (ICAP) Framework, which predicts that interactive and constructive engagement modes produce superior learning outcomes.

From an SDT perspective [17], [18], the consistently positive student perceptions across all phases suggest that the STUDIES model successfully addresses the three basic psychological needs. The autonomy-supportive elements (stages S and U) may explain the high engagement levels observed, consistent with Reeve's [49] finding that autonomy-supportive teaching enhances both motivation and achievement. The competence-building activities (stages D and E) align with Freeman *et al.*'s meta-analytic [50] evidence that active learning increases examination performance by 0.47 SD, while the relatedness-fostering stage I is consistent with Johnson and Johnson's [25] finding that cooperative learning produces higher achievement than individualistic approaches (d=0.66).

### 6.2. Comparison with existing evidence

The effect sizes observed in this study compare favorably with established benchmarks. The normalized gain of 0.64 in Phase III falls within the medium range on Hake's [45] scale and exceeds the average reported in physics education reform studies (typically $\langle g \rangle = 0.48$), while the effectiveness indices of 0.62–0.63 in Phases I–II exceed the conventional threshold of 0.50 for acceptable instructional effectiveness [43]. Krajcik and Shin [10] reported comparable learning gains (d=0.50–0.80) in project-based STEM education, though without the metacognitive development component that the STUDIES model uniquely provides. Srisawasdi and Panjaburee [51] further situated similar findings within Thai educational research, supporting the cross-disciplinary plausibility of the model.

### 6.3. Policy implications and scalability

The STUDIES model addresses structural challenges specific to Thai education while maintaining international transferability. It responds to the Teachers' Council professional standards [6], operationalizes the 20-year national strategy [5], and addresses the PISA 2022 performance gap [4]. For policymakers, the model provides an evidence-based framework for curriculum reform in teacher preparation, with explicit alignment to accreditation requirements and sustainable development goal 4 [40]; for teacher educators, it offers practical guidelines, including curriculum design templates as shown in Table 1, assessment metrics, and a semester implementation roadmap. The modular seven-stage structure allows adaptation across disciplinary contexts without losing theoretical coherence, making it scalable for ASEAN teacher-education reform.

Beyond Thailand, the model has implications for international teacher-education systems responding to Education 5.0 demands. As Hamedani *et al.* [1] noted, Education 5.0 frameworks require contextual validation across diverse settings before broad adoption, and the STUDIES model's successful application across three disciplinary contexts provides preliminary evidence of cross-disciplinary generalizability. Darling-Hammond *et al.* [52] emphasized that effective teacher preparation requires coherent program design, clinical practice, and continuous assessment—elements systematically addressed by the seven-stage architecture.

## 7. LIMITATIONS AND FUTURE RESEARCH

While the cumulative evidence supports the STUDIES model, we must acknowledge several methodological limitations before making broader claims. These limitations and the open questions raised by the present findings directly inform the recommendations for future research. The two subsections collectively define the current boundaries of the model's claims.

### 7.1. Limitations

Several limitations must be acknowledged. First, all three phases utilized one-group pretest–posttest designs, which preclude causal assertions due to the absence of control groups and the possible effects of maturation, history, and testing [41]; the substantial within-group effect sizes (d=3.08–6.17), therefore, require careful interpretation, since between-group comparisons would likely yield smaller effects. Second, sample sizes were relatively small (N=24–30) and drawn from a single regional university, limiting generalizability beyond similar institutional contexts. Third, all outcome measures were researcher-developed instruments, and future studies should incorporate standardized measures with established psychometric properties to support cross-study comparison. Fourth, the studies assessed immediate post-intervention outcomes without longitudinal follow-up, leaving questions about knowledge retention and transfer to classroom practice unaddressed.

### 7.2. Recommendations for future research

Five research directions merit pursuit. First, quasi-experimental studies with nonequivalent control-group designs and rigorous effect-size reporting are needed to establish causal claims. Second, multi-site replication studies across diverse institutional contexts and disciplinary areas would establish external validity. Third, longitudinal research tracking graduates through teaching practicums and into their first years of professional practice would evaluate competency retention and transfer to authentic classroom settings. Fourth, mixed-methods research that includes qualitative methods such as classroom observations, interviews, and reflective journals would help illuminate the psychological processes that mediate metacognitive development at different stages of the model. Fifth, the integration of emerging technologies (generative AI, VR/AR, and learning analytics) within the model's digital learning stage warrants systematic investigation, including ethical safeguards and equity implications. These five directions together make up a clear research agenda for the next ten years of STUDIES model research.

## 8. CONCLUSION

This study presented the STUDIES model: Education 5.0 as a seven-stage instructional framework for teacher education, grounded in constructivism, self-determination theory, and digital humanism. The unique contribution of the model is its empirically validated progressive pathway, in which a single seven-stage architecture is shown to develop knowledge, higher-order thinking, and metacognition—a trajectory mirroring a recognized hierarchical taxonomy and not previously demonstrated by any other Education 5.0 framework. By mapping each stage to one of the five Education 5.0 pillars and to a specific psychological need, the model provides a coherent and reusable architecture for human-centric teacher preparation.

Cumulative evidence across three published validation phases (N=82 in total) demonstrates that the model consistently produces statistically significant improvements in the targeted outcomes, with enormous within-group effect sizes and high student endorsement. However, the pre-experimental designs employed limit causal inference, and the findings should therefore be considered promising rather than conclusive. The alignment of the model with Education 5.0 pillars, with national professional standards, and with the global sustainable development goal for education positions it as a potentially scalable framework for teacher-education reform.

Future research employing quasi-experimental designs, multi-site replications, and longitudinal tracking will be essential to confirm and extend these initial findings. Researchers should focus on integrating emerging technologies, ensuring the long-term retention of metacognitive gains, and assessing the cross-cultural transferability of the seven-stage architecture. Such research will determine whether the present validation in Thai teacher education can serve as a foundation for broader Education 5.0 reform across diverse international contexts.


## FUNDING INFORMATION

Authors state no funding involved.


## AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

| Name of Author | C | M | So | Va | Fo | I | R | D | O | E | Vi | Su | P | Fu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Phichittra Thongpanit | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | |
| Pratya Thongpanit | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | | |
| Sutep Uamcharoen | ✓ | ✓ | | ✓ | | ✓ | | | | ✓ | | | | |

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

## CONFLICT OF INTEREST STATEMENT

Authors state that there is no conflict of interest.

## INFORMED CONSENT

Informed consent was obtained from all individual participants included in this study.

## ETHICAL APPROVAL

The research related to human use complied with all relevant national regulations and institutional policies in accordance with the tenets of the Declaration of Helsinki and was approved by the authors' institutional review board or equivalent committee at Nakhon Phanom University.

## DATA AVAILABILITY

Derived data supporting the findings of this study are available from the corresponding author, [PT], upon reasonable request.

## REFERENCES

[1] S. S. Hamedani, S. Aslam, B. A. M. Oraibi, Y. B. Wah, and S. S. Hamedani, "Transitioning towards Tomorrow's Workforce: Education 5.0 in the Landscape of Society 5.0: a systematic literature review," *Education Sciences*, vol. 14, no. 10, 2024, doi: 10.3390/educsci14101041.

[2] S. Ahmad, S. Umirzakova, G. Mujtaba, M. S. Amin, and T. Whangbo, "Education 5.0: requirements, enabling technologies, and future directions," *arXiv preprint arXiv: 2307.15846*, Jul. 2023.

[3] E. G. Carayannis and J. Morawska-Jancelewicz, "The futures of Europe: Society 5.0 and Industry 5.0 as driving forces of future universities," *Journal of the Knowledge Economy*, vol. 13, no. 4, pp. 3445–3471, Dec. 2022, doi: 10.1007/s13132-021-00854-2.

[4] OECD, *PISA 2022 Results (Volume I). The State of Learning and Equity in Education*. Paris: OECD Publishing, 2023, doi: 10.1787/53f23881-en.

[5] Office of the National Economic and Social Development Council (NESDC), "National strategy (2018–2037)." Accessed: Apr. 15, 2026. [Online]. Available: https://www.nesdc.go.th/wordpress/wp-content/uploads/2025/05/02-National-Strategy-2018-2037.pdf.

[6] Teachers' Council of Thailand, "Notification of the Teachers' Council Board on details of the standards of knowledge and professional experience of teachers under the Regulation of the Teachers' Council of Thailand on Professional Standards (No. 4), B.E. 2562," Royal Thai Government Gazette, vol. 137, 2020. Accessed: Aug. 3, 2026. [Online]. Available: https://ratchakitcha.soc.go.th/documents/17130946.pdf.

[7] G. W. Fry and H. Bi, "The evolution of educational reform in Thailand: The Thai educational paradox," *Journal of Educational Administration*, vol. 51, no. 3, pp. 290–319, 2013, doi: 10.1108/09578231311311483.

[8] S. Chinchorkar and J. Jadhav, "Commentary: transforming Education 4.0 to Education 5.0: sustainable education," *Journal of Research in Innovative Teaching and Learning*, vol. 17, no. 2, pp. 408–413, Aug. 2024, doi: 10.1108/JRIT-09-2024-194.

[9] M. Akour and M. Alenezi, "Higher education future in the era of digital transformation," *Education Sciences*, vol. 12, no. 11, p. 784, Nov. 2022, doi: 10.3390/educsci12110784.

[10] J. S. Krajcik and N. Shin, "Project-based learning," in *The Cambridge Handbook of the Learning Sciences*, Cambridge University Press, 2022, pp. 72–92, doi: 10.1017/9781108888295.006.

[11] M. Mulder, "The concept of competence: blessing or curse?" in *Innovations for competence management*, Lahti: Lahti University of Applied Sciences, 2011, pp. 11–24. [Online]. Available: https://www.mmulder.nl/wp-content/uploads/2011/11/2011-Mulder-Competence-Blessing-or-Curse-in-Torniainen-et-al.pdf.

[12] J. L. Howard, J. Bureau, F. Guay, J. X. Y. Chong, and R. M. Ryan, "Student motivation and associated outcomes: a meta-analysis from self-determination theory," *Perspectives on Psychological Science*, vol. 16, no. 6, pp. 1300–1323, Nov. 2021, doi: 10.1177/1745691620966789.

[13] J. H. Flavell, "Metacognition and cognitive monitoring: a new area of cognitive–developmental inquiry," *American Psychologist*, vol. 34, no. 10, pp. 906–911, Oct. 1979, doi: 10.1037/0003-066X.34.10.906.

[14] G. Schraw and R. S. Dennison, "Assessing metacognitive awareness," *Contemporary Educational Psychology*, vol. 19, no. 4, pp. 460–475, Oct. 1994, doi: 10.1006/ceps.1994.1033.

[15] P. Thongpanit, "Development of the STUDIES model to Promote Instructional and Classroom Management for Undergraduate Students Teachers," (in Thai), *UMT Poly Journal (Journal of Eastern University of Management and Technology)*, vol. 16, no. 1, pp. 529–538, 2019. [Online]. Available: https://so06.tci-thaijo.org/index.php/umt-poly/article/view/201788.

[16] G. W. Gagnon and M. Collay, *Designing for learning: six elements in constructivist Classrooms*. Corwin Press, 2001.

[17] R. M. Ryan and E. L. Deci, "Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being," *American Psychologist*, vol. 55, no. 1, pp. 68–78, 2000, doi: 10.1037/0003-066X.55.1.68.

[18] R. M. Ryan and E. L. Deci, "Intrinsic and extrinsic motivation from a self-determination theory perspective: definitions, theory, practices, and future directions," *Contemporary Educational Psychology*, vol. 61, p. 101860, Apr. 2020, doi: 10.1016/j.cedpsych.2020.101860.

[19] S. S. Scott, J. M. Mcguire, and S. F. Shaw, "Universal design for instruction," *Remedial and Special Education*, vol. 24, no. 6, pp. 369–379, Nov. 2003, doi: 10.1177/07419325030240060801.

[20] R. J. Marzano and J. S. Kendall, *The new taxonomy of educational objectives*, 2nd ed. Thousand Oaks, CA: Corwin Press, 2007.

[21] S. Adipat, "Transcending traditional paradigms: the multifaceted realm of phenomenon-based learning," *Frontiers in Education*, vol. 9, Jan. 2024, doi: 10.3389/feduc.2024.1346403.

[22] P. Mishra and M. J. Koehler, "Technological pedagogical content knowledge: a framework for teacher knowledge," *Teachers College Record: The Voice of Scholarship in Education*, vol. 108, no. 6, pp. 1017–1054, 2006, doi: 10.1111/j.1467-9620.2006.00684.x.

[23] L. S. Vygotsky, *Mind in society: development of higher psychological processes*. Cambridge: Harvard University Press, 1978.

[24] O. Zawacki-Richter, V. I. Marín, M. Bond, and F. Gouverneur, "Systematic review of research on artificial intelligence applications in higher education–where are the educators?" *International Journal of Educational Technology in Higher Education*, vol. 16, no. 1, p. 39, Dec. 2019, doi: 10.1186/s41239-019-0171-0.

[25] D. W. Johnson and R. T. Johnson, "An educational psychology success story: social interdependence theory and cooperative learning," *Educational Researcher*, vol. 38, no. 5, pp. 365–379, Jun. 2009, doi: 10.3102/0013189X09339057.

[26] N. Strangeman, C. Hitchcock, and G. M. T. Hall, "Response-to-instruction and universal design for learning: How might they intersect in the general education classroom?" The Access Center, Washington, DC, 2006. Accessed: Apr. 15, 2026. [Online]. Available: https://www.readingrockets.org/topics/curriculum-and-instruction/articles/response-instruction-and-universal-design-learning-how.

[27] L. W. Anderson, D. R. Krathwohl, and B. S. Bloom, *A taxonomy for learning, teaching, and assessing: a revision of Bloom's taxonomy of educational objectives*. New York, NY: Longman, 2001.

[28] M. V. J. Veenman, B. H. A. M. Van Hout-Wolters, and P. Afflerbach, "Metacognition and learning: conceptual and methodological considerations," *Metacognition and Learning*, vol. 1, no. 1, pp. 3–14, Apr. 2006, doi: 10.1007/s11409-006-6893-0.

[29] C. Dignath, G. Buettner, and H.-P. Langfeldt, "How can primary school students learn self-regulated learning strategies most effectively?" *Educational Research Review*, vol. 3, no. 2, pp. 101–129, Jan. 2008, doi: 10.1016/j.edurev.2008.02.003.

[30] X. Huang, H. Li, L. Huang, and T. Jiang, "Research on the development and innovation of online education based on digital knowledge sharing community," *BMC Psychology*, vol. 11, no. 1, p. 295, Sep. 2023, doi: 10.1186/s40359-023-01337-6.

[31] J. Hattie, *Visible Learning: A Synthesis of over 800 Meta-Analyses Related to Achievement*. London: Routledge, 2009, doi: 10.4324/9780203887332.

[32] L. Zheng, "The effectiveness of self-regulated learning scaffolds on academic performance in computer-based learning environments: a meta-analysis," *Asia Pacific Education Review*, vol. 17, no. 2, pp. 187–202, 2016, doi: 10.1007/s12564-016-9426-9.

[33] D. H. Jonassen, M. Tessmer, and W. H. Hannum, *Task analysis methods for instructional design*. New York: Routledge, 1998, doi: 10.4324/9781410602657.

[34] G. Wiggins and J. McTighe, *Understanding by design*, 2nd ed. ISTE ASCD, 2005.

[35] R. Razzouk and V. Shute, "What is design thinking and why is it important?" *Review of Educational Research*, vol. 82, no. 3, pp. 330–348, Sep. 2012, doi: 10.3102/0034654312457429.

[36] R. Fogarty, "Ten ways to integrate curriculum," *Educational Leadership*, vol. 49, no. 2, pp. 61–65, 1991.

[37] P. Black and D. Wiliam, "Assessment and classroom learning," *Assessment in Education: Principles, Policy & Practice*, vol. 5, no. 1, pp. 7–74, Mar. 1998, doi: 10.1080/0969595980050102.

[38] R. J. Marzano, D. Pickering, and J. E. Pollock, *Classroom instruction that works: Research-based strategies for increasing student achievement*. Alexandria, VA: ASCD, 2001.

[39] J. B. Biggs and K. F. Collis, *Evaluating the quality of learning*. Elsevier, 1982, doi: 10.1016/C2013-0-10375-3.

[40] UNESCO, *Reimagining our futures together: a new social contract for education*. Paris: UNESCO Publishing, 2021, doi: 10.54675/ASRB4722.

[41] D. T. Campbell and J. C. Stanley, *Experimental and Quasi-Experimental Designs for Research*. Boston: Houghton Mifflin, 1963.

[42] T. R. Guskey, *Implementing Mastery Learning*, 3rd ed. Thousand Oaks, CA: Corwin Press, 2023.

[43] R. I. Goodman, K. A. Fletcher, and E. W. Schneider, "The effectiveness index as a comparative measure in media product evaluation," *Educational Technology*, vol. 20, no. 9, pp. 30–34, 1980.

[44] F. Faul, E. Erdfelder, A.-G. Lang, and A. Buchner, "G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences," *Behavior Research Methods*, vol. 39, no. 2, pp. 175–191, 2007, doi: 10.3758/BF03193146.

[45] R. R. Hake, "Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," *American Journal of Physics*, vol. 66, no. 1, pp. 64–74, Jan. 1998, doi: 10.1119/1.18809.

[46] P. Thongpanit, "The development of a teaching and learning paradigm that promotes higher-order thinking skills in the age of Education 4.0 Among Education Students," *Silpakorn Educational Research Journal*, vol. 11, no. 2, pp. 179–198, 2019.

[47] P. Thongpanit and P. Thongpanit, "A phenomenon-based learning management model integrating a digital learning ecosystem to enhance metacognition for pre-service teachers," *Asian Journal of Education and Training*, vol. 12, no. 1, pp. 14–20, Jan. 2026, doi: 10.20448/edu.v12i1.8084.

[48] M. T. H. Chi and R. Wylie, "The ICAP framework: linking cognitive engagement to active learning outcomes," *Educational Psychologist*, vol. 49, no. 4, pp. 219–243, Oct. 2014, doi: 10.1080/00461520.2014.965823.

[49] J. Reeve, "A self-determination theory perspective on student engagement," in *Handbook of Research on Student Engagement*, Boston, MA: Springer US, 2012, pp. 149–172. doi: 10.1007/978-1-4614-2018-7_7.

[50] S. Freeman *et al.*, "Active learning increases student performance in science, engineering, and mathematics," *Proceedings of the National Academy of Sciences*, vol. 111, no. 23, pp. 8410–8415, Jun. 2014, doi: 10.1073/pnas.1319030111.

[51] N. Srisawasdi and P. Panjaburee, "Implementation of game-transformed inquiry-based learning to promote the understanding of and motivation to learn chemistry," *Journal of Science Education and Technology*, vol. 28, no. 2, pp. 152–164, Apr. 2019, doi: 10.1007/s10956-018-9754-0.

[52] L. Darling-Hammond, L. Flook, C. Cook-Harvey, B. Barron, and D. Osher, "Implications for educational practice of the science of learning and development," *Applied Developmental Science*, vol. 24, no. 2, p. 97, 2020, doi: 10.1080/10888691.2018.1537791.


## BIOGRAPHIES OF AUTHORS

**Phichittra Thongpanit** is an academic and researcher specializing in pedagogical innovation, curriculum development, and classroom management. She is key in changing education to focus on 21st-century skills by using digital learning tools, teamwork, and self-reflection in learning. With a consistent record of publications in national and international academic journals, her work is highly recognized globally, evidenced by an outstanding citation record—notably, her 2024 research on enhancing analytical and critical thinking skills. These scholarly contributions underscore her expertise and dedication to creating impactful instructional innovations that tangibly elevate student capabilities. She can be contacted at email: phichittra@npu.ac.th.

**Pratya Thongpanit** is an academic and researcher specializing in educational administration and pedagogical innovation. With a Doctor of Education and a foundational background in physics, he effectively bridges analytical inquiry with educational advancement. His research focuses on elevating educational quality through advanced instructional models—notably the NPU and NSW learning paradigms—to foster 21st-century higher-order thinking skills. Additionally, his research looks at how to use digital learning tools to improve self-awareness in future teachers, as well as important studies on inclusive education, helping students catch up on learning, and new leadership measures for school leaders. Widely published in recognized international journals, his contributions demonstrate a steadfast commitment to advancing educational leadership and the teaching profession. He can be contacted at email: p.thongpanit@npu.ac.th.

**Sutep Uamcharoen** is an esteemed academic and researcher specializing in curriculum research and development, educational technology, and instructional innovation. Holding a Doctor of Education (Ed.D.), he plays a pivotal role in shaping graduate-level education by developing and managing master's and doctoral programs at leading institutions. His scholarly research focuses on advancing educational quality through blended learning approaches and fostering democratic leadership and knowledge management skills among pre-service teachers in the Education 5.0 era. With a consistent record of publications in recognized academic journals, his contributions reflect a profound commitment to driving pedagogical advancements and elevating the teaching profession. He can be contacted at email: sutep.sedu@gmail.com.