

Exploring the Pathways for Cultivating Digital Instructional Design Competencies in Foreign Language Pre-service Teachers through Generative AI

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Abstract: The rapid proliferation of generative artificial intelligence (GenAI) tools is profoundly reshaping the knowledge base and practical landscape of foreign language teacher education. While pre-service teachers have acquired basic familiarity with AI applications, their capacity to embed AI throughout the entire instructional design process and achieve deep human-AI collaboration remains underdeveloped. Drawing upon the Technological Pedagogical Content Knowledge (TPACK) framework and its extended form in the AI context—Intelligent-TPACK, and informed by the iterative design logic of Microteaching Lesson Study (MLS), this paper constructs a four-stage closed-loop cultivation pathway: “AI collaborative lesson planning—simulated teaching—AI-assisted reflection—instructional revision.” The study proposes that the effectiveness of the cultivation pathway hinges on the synergistic advancement of four dimensions: the integration of foundational AI literacy with pedagogical frameworks, systematic training in pedagogical prompt engineering, cultivation of critical evaluation competencies for AI-generated content, and the development of practical habits of reflective adaptation and iterative refinement. The pathway emphasizes that GenAI should not replace teachers’ design thinking but rather serve as a cognitive scaffold for developing pedagogical judgment and professional autonomy, offering a replicable operational framework for cultivating digital intelligence competencies in foreign language pre-service teachers.

Keywords: generative artificial intelligence; foreign language pre-service teachers; digital instructional design; Intelligent-TPACK

0. Introduction

The rapid rise of generative artificial intelligence has pushed foreign language teacher education to a historical juncture where the core competencies and cultivation pathways must be re-examined. In 2025, the Chinese Ministry of Education issued the Notice on Organizing the Implementation of the Digital Empowerment Teacher Development Action, which explicitly stipulated that “digital literacy and intelligent literacy” should be incorporated as core competencies into the professional standards for pre-service teachers. The Henan Provincial Teacher Education Quality Improvement Action Plan also identifies the reform of outstanding teacher cultivation as a key priority. The cultivation of digital and intelligent competencies in pre-service teachers has thus shifted from general advocacy to a new stage of standardized, systematic implementation. Against this backdrop, exploring the deep integration pathways between GenAI and pre-service teacher cultivation has become a frontier issue in teacher education reform.

However, existing research indicates that although pre-service teachers hold positive attitudes toward AI-assisted teaching, their actual application remains at superficial levels such as vocabulary list generation and basic exercise creation. AI intervention has not permeated the key stages of instructional design, including objective setting, activity sequencing, and reflective revision. A deeper issue is that AI-generated lesson plans tend to exhibit formulaic structures that primarily facilitate lower-order thinking activities. Whether GenAI can genuinely promote the development of deep instructional design competencies depends critically on the design of embedding strategies and usage patterns^[4]. Kohnke et al. confirmed that pre-service teachers

generally favor simple queries over deep collaboration when using AI, and that traditional training models remain overly general, failing to provide progressive, experiential AI integration training.

Instructional design competency constitutes the core of pre-service teachers' professional competence. In the GenAI era, cultivating this competency faces three challenges: first, how to embed AI tools throughout the complete instructional design chain of "objective setting—activity design—simulated implementation—reflective revision," making them an organic component supporting the entire design process; second, how to guide pre-service teachers beyond the polarized tendencies of either "uncritical acceptance" or "complete rejection," fostering critical and reflective human-AI collaboration habits; third, following AI intervention, how to establish competency-oriented assessment criteria that distinguish AI contributions from learners' own design competency development.

This paper attempts to address these questions. Drawing upon the iterative framework of international Microteaching Lesson Study and integrating the Intelligent-TPACK theoretical model, it constructs and elaborates a four-stage closed-loop cultivation pathway of "AI collaborative lesson planning—simulated teaching—AI-assisted reflection—instructional revision," providing an actionable operational framework for cultivating digital intelligence competencies in foreign language pre-service teachers. The paper is organized as follows: Section 2 elaborates the theoretical foundations; Section 3 analyzes the current state and problems of pre-service teacher competency preparedness; Section 4 details the core framework and implementation mechanisms of the cultivation pathway; Section 5 discusses key implementation issues and coping strategies; and the final section concludes the paper.

1. Theoretical Foundations

1.1 The TPACK Framework and Its Extension in the AI Context

The Technological Pedagogical Content Knowledge (TPACK) framework, proposed by Mishra and Koehler, provides a classical theoretical perspective for understanding the knowledge base required for effective technology integration in teaching. The framework articulates the complex interrelationships among technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK), and argues that successful technology integration requires a comprehensive understanding of these three domains and their intersections.

Against the backdrop of increasing AI applications in education, researchers have extended the TPACK framework. Celik, through empirical examination of widely used AI tools (chatbots, intelligent tutoring systems, automated assessment systems, etc.), redefined the components of the classical TPACK in the AI context and added an Ethical Knowledge dimension, forming the Intelligent-TPACK framework. He found that ethical awareness is not merely an adjunct to TPACK but exerts an influence on teachers' AI integration decisions comparable to that of pedagogical knowledge^[2].

The core components of the Intelligent-TPACK framework are as follows: Intelligent-TK concerns teachers' foundational understanding of AI system mechanisms, including awareness of AI tool functionalities, limitations, and ethical risks; Intelligent-TPK focuses on how teachers employ AI to enhance pedagogical strategies, including designing AI-supported personalized learning and automated feedback interventions; Intelligent-TCK addresses teachers' understanding of how AI reshapes the representation and instructional practice of disciplinary knowledge; Intelligent-TPACK represents the systematic professional competence to select, adapt, and evaluate AI tools based on instructional objectives and disciplinary characteristics through the integrated application of the above knowledge; and Ethical Knowledge requires teachers to evaluate AI tools' educational applications according to principles of fairness, transparency, privacy, and accountability.

The relevance of the Intelligent-TPACK framework lies in its dual response to the expanded

knowledge structure demands of the GenAI era and its incorporation of ethical and critical reflection as core competency dimensions, thereby avoiding a narrow technological determinism. Bümen and Yedigöz Kara further confirmed that after embedding GenAI into the iterative cycle of Microteaching Lesson Study, pre-service teachers demonstrated significant growth across all TPACK dimensions, particularly in Intelligent-TPK and Intelligent-TCK, with effect sizes reaching moderate to large levels ($d = 0.99-1.99$)^[1].

1.2 The Iterative Logic of Microteaching Lesson Study

Microteaching Lesson Study (MLS) is a teacher education model that combines Microteaching with Lesson Study, with its core characteristic being the iterative cycle of “planning—teaching—observation—reflection—revision.” Recent research has confirmed that embedding GenAI into the MLS iterative cycle can significantly promote pre-service teachers’ development across multiple dimensions, including instructional design competency, AI literacy, and teaching self-efficacy.

In 2026, Bümen and Yedigöz Kara employed a mixed-methods intervention design, conducting two MLS cycles with pre-service teachers. Quantitative analysis revealed significant improvements in participants’ individual innovativeness, teaching self-efficacy, TPACK instructional practice, AI literacy, and lesson planning competence, with effect sizes ranging from 0.99 to 1.99. The study noted that GenAI-supported MLS, positioned within the iterative collaborative cycle of planning, implementation, and reflection, yields benefits that transcend efficiency-oriented AI use and effectively promotes the multidimensional development of pre-service teachers’ professional competencies^[1].

The iterative logic of MLS provides a natural framework for embedding GenAI. In the traditional MLS model, reflection and revision rely on peer observation and instructor feedback. With GenAI intervention, pre-service teachers can obtain structured analytical reports from AI during the reflection phase—diagnostic information on lesson segment transitions, question type distribution, teacher-student interaction patterns, etc.—thereby enriching the information base for reflection and making revision more targeted. Jou et al. found that after integrating GenAI tools into the MLS framework, participating teachers demonstrated significant growth across all TPACK dimensions and gradually came to understand AI as a “co-participant” in instructional design rather than merely a tool^[3].

The four-stage closed-loop “AI collaborative lesson planning—simulated teaching—AI-assisted reflection—instructional revision” designed in this study precisely combines the iterative logic of MLS with the functional characteristics of GenAI tools, aiming to bridge the translation channel between technological learning and instructional practice.

2. Current State and Problem Analysis of Pre-service Teacher Competency Preparedness

2.1 Current State

Synthesizing classroom observations of English education majors and relevant empirical studies^[4]^[6], the following characteristics emerge regarding pre-service teachers’ current use of GenAI in instructional design.

On the positive side, pre-service teachers generally demonstrate high enthusiasm for AI. Tristiana et al., in a study of 17 pre-service teachers using AI tools to design TEFL methodology lessons, found that participants reported positive experiences including enhanced creativity, improved efficiency, and technology competency development. Commonly used AI tools included ChatGPT, Gemini, Canva AI, Grammarly, QuillBot, and Microsoft Copilot^[6].

However, deep-seated problems cannot be overlooked. First, superficiality of usage level. Most pre-service teachers employ AI for routine tasks such as vocabulary list generation and reading comprehension question creation, rarely applying it to instructional design tasks requiring design

judgment, such as tiered objective setting, logical sequencing of activity progressions, and differentiated assessment design. Kohnke et al.'s microlearning case study confirmed that learners initially using AI generally favor simple queries over deep collaboration, and that existing teacher education programs lack structured approaches to cultivating pre-service teachers' AI literacy and pedagogical adaptation competencies.

Second, weakness in critical evaluation competency. Tristiana et al. identified challenges faced by pre-service teachers when using AI, including over-reliance on AI, content accuracy concerns, plagiarism risks, and ethical issues. Pre-service teachers often uncritically adopt AI-generated lesson plans, lacking sensitivity to potential issues such as linguistic inaccuracies, cultural biases, and problematic activity design logic. The Intelligent-TPACK framework's inclusion of Ethical Knowledge as an independent dimension directly responds to this problem.

Third, absence of AI in the reflection phase. In current pre-service teacher instructional design training, AI intervention is largely concentrated in the "lesson planning" stage, while AI remains almost entirely absent from the "reflection-revision" phase following simulated teaching. Students rely on self-review and peer feedback for reflection, but constrained by limited experience and perspectives, they often struggle to identify deep structural problems in their instructional designs.

2.2 Causal Analysis

The causes of the above problems can be understood at three levels.

At the curriculum level, most teacher education programs have not yet established systematic designs that integrate AI throughout the entire instructional design training process. Related training predominantly focuses on "tool function introduction" and "operational demonstration," lacking structured training arrangements that embed AI usage into the "design—implementation—reflection—revision" iterative cycle. Tristiana et al. also emphasized the need to integrate AI literacy and critical digital pedagogy into TEFL teacher education programs to promote responsible, effective, and pedagogically sound AI technology use.

At the teacher level, teacher educators themselves remain in the early stages of accumulating experience in AI-assisted instructional design, lacking evidence-based understanding of "which embedding approaches are most effective." Jou et al. found that teacher educators face challenges not only at the technical operational level but also in designing pedagogical frameworks to guide pre-service teachers from "tool use" toward "design reasoning."

At the assessment level, existing assessment systems largely focus on the quality of final lesson plan products, rarely tracking the design process—particularly the manner and extent of AI intervention and learners' processing strategies for AI outputs. The absence of process-oriented assessment prevents learners from obtaining effective feedback on the development of their own design thinking.

3. Core Framework of the Cultivation Pathway

Based on the competency objectives of the Intelligent-TPACK framework and the iterative logic of MLS, this study designs a four-stage closed-loop cultivation pathway: "AI collaborative lesson planning—simulated teaching—AI-assisted reflection—instructional revision." The core mechanisms and implementation points of each stage are as follows.

3.1 AI Collaborative Lesson Planning: Tripartite Collaborative Knowledge Construction

The core mechanism of the collaborative lesson planning stage lies in constructing a tripartite collaborative knowledge construction space among "pre-service teachers—peers—AI." This design responds to the integration requirements of Intelligent-TPK and Intelligent-TCK within the Intelligent-TPACK framework.

The specific operational process is as follows: pre-service teachers engage in multiple rounds of interaction with AI around a specific teaching topic. First, they submit structured prompts to AI articulating instructional design requirements—including target grade level, language proficiency, lesson type, key linguistic knowledge points, activity duration and format parameters. After obtaining the initial AI output, pre-service teachers conduct a preliminary evaluation of the plan, identifying strengths and areas for improvement. Subsequently, they enter the group collaboration phase, comparing each other's process records of interaction with AI, analyzing the strengths and limitations of AI-generated plans, reaching improvement consensus through discussion, and forming a revised version. Finally, AI is introduced as a “second opinion” reference, providing supplementary diagnosis of the group's revised plan.

The key support for this stage lies in systematic training of pedagogical prompt engineering. Kohnke et al. demonstrated that when the above elements are incorporated into prompts, the pedagogical utility of AI outputs significantly improves, and participants effectively mitigated challenges related to AI tool limitations and content accuracy through optimized prompt engineering techniques. Training should include the following elements: (1) learner profile description—language proficiency, age, learning preferences, and prior knowledge; (2) clear articulation of learning objectives—distinguishing different types of objectives such as knowledge acquisition and skill development; (3) activity parameter specification—interaction modes, time allocation, and required resources; (4) pedagogical principle embedding—communicative orientation, task authenticity, or scaffolding requirements^[4].

The design intent of this stage is to ensure that pre-service teachers do not passively accept AI outputs but progressively develop analytical understanding of instructional design through the recursive process of dialoguing with AI, discussing with peers, and re-engaging with AI. Jou et al. found that pre-service teachers' reflective journals revealed a cognitive evolution in their understanding of AI's role—from an initial “answer-getting tool” to gradually becoming a “dialogue partner for instructional design reasoning.”

3.2 Simulated Teaching: From Knowledge to Competency

The simulated teaching stage represents the critical juncture where instructional design transforms from textual plans to pedagogical action. Pre-service teachers implement the lesson plans produced during the AI collaborative lesson planning stage in microteaching classrooms or digital language laboratories, with full video recording. During the teaching process, pre-service teachers face simulated learner responses and make real-time adjustments to planned activities.

The disciplinary specificity of foreign language simulated teaching deserves particular attention. Unlike general subject teaching, foreign language instructional design involves categorized skill training (listening, speaking, reading, writing), dynamic control of material difficulty, communicative activity scenario design, and integration of intercultural content. These disciplinary specificities mean that AI-assisted instructional design cannot simply apply generic templates but requires deep engagement of pedagogical content knowledge. The simulated teaching stage is precisely the key field for testing the integration of disciplinary knowledge and technological tools—whether AI-generated communicative activities genuinely promote meaning negotiation, whether AI-recommended materials are appropriate in difficulty and topic—these questions can only be effectively tested in authentic teaching situations.

Bümen and Yedigöz Kara confirmed that after two MLS cycles, pre-service teachers showed moderate to large effect size improvements in lesson planning competence and teaching practice. Simulated teaching serves as the critical site for testing the integration of disciplinary knowledge and technological tools.

3.3 AI-Assisted Reflection: Structured Diagnosis and Multi-dimensional Referencing

AI-assisted reflection is the core innovative stage in the four-stage closed loop that distinguishes

it from traditional instructional design training. Its design rationale is to input textual records of the teaching process into AI tools, obtaining structured analytical reports on lesson segment transitions, question type frequency distribution, student participation patterns, time allocation rationality, etc., as reference information for pre-service teachers' reflection.

The specific operational process comprises the “self-reflection + peer feedback + AI diagnosis + instructor feedback” four-dimensional reflection mechanism: pre-service teachers review teaching videos and complete self-reflection records; peers provide feedback from the observer perspective; pre-service teachers input key teaching process information into AI tools to obtain automated analytical reports; instructors provide comprehensive feedback synthesizing the three sources to help pre-service teachers focus on core improvement directions.

This stage particularly involves the Ethical Knowledge dimension of the Intelligent-TPACK framework. Celik emphasized that teachers must conduct ethical evaluations of AI tools—including transparency (understanding the process and reasons for AI decisions), accountability (identifying the creators and responsibility attribution of AI outputs), inclusivity (attending to how AI addresses diversity, inclusion, and individual differences), and fairness (evaluating whether AI tools treat all students equitably). Cultivating pre-service teachers' critical reception of AI diagnostic information, enabling them to treat AI reports as “mirrors” rather than “final judgments” of reflection, is the core educational objective of this stage^[2].

3.4 Instructional Revision: Completing the Loop and Initiating Iteration

Instructional revision is the end point of the closed loop and the starting point of the next iteration. Pre-service teachers synthesize self-reflection, peer feedback, AI diagnosis, and instructor feedback to make targeted revisions to the original lesson plan. The revision process requires preserving complete process documentation of “initial lesson plan—AI suggestion records—simulated teaching recordings—reflective journals—revised final plan,” forming a personal instructional design competency development portfolio.

The value of revision lies not only in plan optimization but more importantly in cultivating the professional habit of “evidence-based design decision-making.” Each revision requires pre-service teachers to explicitly state “what was changed” and “why it was changed,” anchoring decision-making rationales to specific information sources in the four-dimensional reflection, thereby progressively establishing evidence-based design judgment.

Each student completes no fewer than two full closed-loop cycles per semester. Bümen and Yedigöz Kara confirmed that after two iterative cycles, pre-service teachers demonstrate significant improvements in instructional design competency, AI literacy, and teaching self-efficacy. Huang and Cao also found that after multiple iterative training cycles, the precision and complexity of pre-service teachers' prompt writing were closely related to their digital instructional design competency development, and that configurational pathways such as “human-AI collaborative-driven type” and “teacher-led type” effectively drove pre-service teachers' digital instructional design competency development.

4. Key Implementation Issues and Coping Strategies

4.1 How to Prevent AI Replacing Rather Than Supporting Design Thinking

The greatest risk in implementing the cultivation pathway is that pre-service teachers may view AI as a replacement for rather than an aid to design work. To address this risk, design is needed at two levels.

At the task design level, AI outputs should be emphasized as “design starting points” rather than “final plans.” The collaborative lesson planning stage requires pre-service teachers to conduct written evaluations of AI drafts—identifying at least three strengths and three areas for improvement,

with justifications for modifications. The revision stage following simulated teaching requires pre-service teachers to clearly annotate each modification and its evidentiary basis. This mandatory “evaluate—modify—justify” design compels pre-service teachers to remain in the position of active design decision-makers.

At the assessment orientation level, process-oriented assessment should focus on tracking pre-service teachers’ processing strategies for AI outputs rather than the quality of the outputs themselves. Bümen and Yedigöz Kara employed a mixed-methods design combining quantitative pre-test/post-test with qualitative evidence analysis, effectively revealing the developmental trajectories of pre-service teachers’ professional competencies. Shifting the assessment focus from “product” to “process” and “thinking” is the key institutional design for preventing AI from replacing design thinking ^[1].

4.2 How to Address AI Hallucinations and Content Inaccuracies

GenAI tools may generate factual errors, linguistic inaccuracies, or cultural biases when producing instructional content. Coping strategies encompass both technical and pedagogical dimensions.

At the technical level, pre-service teachers should be trained in basic AI output verification methods, including cross-validation (comparing outputs from different AI tools on the same question), source verification, and language proofreading. In 2025, Kohnke et al. found that participants effectively mitigated challenges related to tool limitations and content accuracy through cross-validation of AI outputs. At the pedagogical level, pre-service teachers should be guided to incorporate “identifying AI errors” into their instructional design competency development objectives, exposing them through case-based teaching to various AI-generated “problematic lesson plans” and enhancing critical sensitivity through error identification and correction training.

4.3 How to Establish Competency-Oriented Assessment Criteria

Following GenAI intervention, the assessment of instructional design competency faces a new methodological challenge: which components of the lesson plan belong to students’ own design competencies, which are AI contributions, and how to distinguish and measure them?

The coping strategy is to establish a “process portfolio + multidimensional scoring” assessment system. The process portfolio comprehensively documents “initial lesson plan—AI suggestion records—simulated teaching recordings—reflective journals—revised final plan” for each closed loop, enabling evaluators to trace the formation process of the design and determine the degree of pre-service teachers’ contribution. Multidimensional scoring involves tripartite evaluation by instructors, peers, and pre-service teachers themselves, with assessment dimensions including: final quality of the instructional design plan (outcome indicator), rationality of AI output processing strategies (process indicator), and depth of design reasoning reflected in reflective journals (cognitive indicator). Celik’s Intelligent-TPACK scale provides an actionable theoretical framework and measurement instrument for multidimensional assessment.

5. Conclusion

The cultivation of digital instructional design competencies in foreign language pre-service teachers through generative AI represents both a practical response to educational digital transformation and an active exploration of the paradigm of foreign language teacher education. The key lies in transcending the instrumental thinking of “AI helping to write lesson plans” and embedding AI into the iterative cycle of “design—implementation—reflection—revision,” enabling pre-service teachers to progressively develop critical and reflective design habits through repeated human-AI collaborative practice.

Based on the Intelligent-TPACK theoretical framework and the iterative logic of Microteaching Lesson Study, this paper constructs a four-stage closed-loop cultivation pathway of “AI collaborative lesson planning—simulated teaching—AI-assisted reflection—instructional revision.” The core philosophy of this pathway is that GenAI should not replace teachers’ design thinking but rather serve as a cognitive scaffold for developing pedagogical judgment and professional autonomy. Each of the four stages bears a different competency development function—collaborative lesson planning cultivates human-AI collaboration and pedagogical prompt engineering competency; simulated teaching realizes the translation of knowledge into action; AI-assisted reflection provides structured diagnosis and multi-dimensional referencing; and instructional revision promotes the development of evidence-based design decision-making habits.

Bümen and Yedigöz Kara confirmed that the systematic integration of GenAI into the MLS iterative cycle represents a significant breakthrough in pre-service teacher professional development, with practical significance beyond efficiency-oriented AI applications. Huang and Cao also found that GenAI can significantly enhance pre-service teachers’ digital instructional design competency, with prompt precision and complexity being key influencing factors. The key implementation risks—AI replacing design thinking, AI hallucinations and content inaccuracies, and the absence of competency-oriented assessment criteria—must be addressed through strategies such as task design, verification training, and assessment system reform. Only through sustained practical testing and refinement can the cultivation pathway truly evolve from plan to effectiveness, from experience to transferable professional knowledge.

Author Biography

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