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Effectiveness of AI-Assisted CLIL Instruction on Developing Methodological Competence in Pre-Service EFL Teachers: A Mixed-Methods Study

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ABSTRACT: This study addresses a persistent gap in teacher education research: although artificial intelligence is increasingly incorporated into language pedagogy, limited evidence exists on how AI-supported instruction contributes to the methodological competence of pre-service EFL teachers, particularly within Content and Language Integrated Learning (CLIL) environments. The study investigates whether and how AI-assisted CLIL instruction supports the development of pedagogical planning, material design, assessment awareness, and reflective decision-making in teacher preparation. The analysis is informed by an integrated framework combining CLIL pedagogy, sociocultural

learning theory, teacher competence theory, and technology-mediated pedagogical knowledge.

A mixed-methods design was employed to capture both measurable change and interpretive depth. The study was conducted with pre-service EFL teachers enrolled in a teacher education program, where AI-supported CLIL tasks were embedded into methodology-oriented coursework. Quantitative data were gathered through pre- and post-intervention measures of methodological competence, while qualitative data drew on reflective writing, instructional artifacts, and participant interviews to examine how the intervention shaped pedagogical thinking and practice.

The findings indicate that AI-assisted CLIL instruction can strengthen methodological competence when technology is used as a scaffold for pedagogical reasoning rather than as a shortcut for task completion. Participants showed improvement in lesson structuring, integration of language and content objectives, and critical reflection on instructional design, while also reporting tensions related to overreliance on AI-generated suggestions. The study contributes theoretically by linking AI use to situated teacher learning, and pedagogically by clarifying how AI can be integrated into CLIL-based teacher education in ways that support, rather than replace, developing professional judgment.

INTRODUCTION

Teacher education is being reshaped by a broader pedagogical shift in which digital tools are no longer treated as supplementary supports but as environments within which instructional thinking, classroom design, and professional learning increasingly occur. This shift has become particularly consequential in language teacher education, where future teachers are expected not only to use technology functionally but also to evaluate its pedagogical value, adapt it to instructional aims, and integrate it into context-sensitive teaching practice. In such settings, the question is no longer whether technology should be present in teacher preparation, but how it reconfigures the development of professional competence, especially in relation to planning, mediation, and reflective judgment (Koehler & Mishra, 2009; Tondeur et al., 2012). The rapid expansion of artificial intelligence has intensified this question by introducing tools that can generate lesson ideas, scaffold materials, simulate feedback, and reshape the relationship between pedagogical decision-making and technological support.

Within language pedagogy, AI has attracted growing attention for its potential to personalize learning, extend access to instructional support, and increase efficiency in content generation and feedback processes. Yet much of the current discourse remains polarized between technological optimism and cautionary critique. What is often missing is a more pedagogically grounded account of how AI influences the formation of teaching competence in pre-service contexts. In EFL teacher education, this issue is especially important because future teachers must learn not merely to consume digital outputs but to make principled methodological choices about language instruction, classroom interaction, task design, and assessment. AI may support this process, but it may also encourage superficial pedagogical dependence if introduced without a strong conceptual framework. For that reason, examining AI in teacher education requires moving beyond generic narratives of innovation toward a more precise understanding of how it shapes professional learning in specific pedagogical models (Luckin et al., 2016; Holmes, Bialik, & Fadel, 2019).

One such model is **Content and Language Integrated Learning (CLIL)**, which remains pedagogically significant in EFL contexts because it requires teachers to manage the simultaneous integration of content objectives, language development, interactional scaffolding, and cognitively appropriate task design. CLIL is not simply a method for increasing language exposure; it is a demanding pedagogical framework that requires future teachers to think across disciplinary knowledge, linguistic mediation, and classroom methodology (Coyle, Hood, & Marsh, 2010). For pre-service EFL teachers, learning to teach through CLIL therefore represents a particularly revealing site for the development of **methodological competence** - understood here as the ability to design, justify, adapt, and evaluate instructional choices in relation to pedagogical goals, learner needs, and contextual demands. Because CLIL pedagogy is structurally complex, it provides an especially useful context for investigating whether AI can function as a meaningful scaffold for methodological growth rather than merely as a productivity tool.

The intersection of **AI-assisted instruction** and **CLIL-oriented teacher preparation** remains underexamined in current scholarship. Existing research has explored AI in language learning, teacher perceptions of educational technology, and the implementation of CLIL in school and university contexts, but far less attention has been given to how AI-supported CLIL work may influence the methodological development of pre-service EFL teachers. This gap is significant because the pedagogical demands of CLIL - especially the coordination of language, content, and classroom process - create conditions in which AI may either deepen professional reasoning or weaken it through overreliance on automated suggestions. What is needed, therefore, is an empirically grounded account of how future teachers engage with AI within a pedagogically demanding instructional framework, and whether such engagement supports the development of reflective, adaptable, and methodologically sound teaching practice (Koehler, Mishra, & Cain, 2013; Tseng, Liao, & Yeh, 2019).

Against this background, the present study investigates the **effectiveness of AI-assisted CLIL instruction in developing methodological competence among pre-service EFL teachers** through a mixed-methods design. The article argues that AI becomes educationally meaningful in teacher preparation not when it simply accelerates task completion, but when it is embedded in structured pedagogical activity that requires future teachers to interpret, critique, adapt, and justify instructional choices. More specifically, the study examines whether AI-assisted CLIL instruction contributes to measurable and perceived growth in methodological competence, how participants experience the role of AI in lesson planning and pedagogical reasoning, and what tensions emerge as they negotiate the relationship between technological assistance and professional judgment. In doing so, the article addresses the following questions: **(1)** To what extent does AI-assisted CLIL instruction influence the methodological competence of pre-service EFL teachers? **(2)** Which dimensions of methodological competence - such as lesson planning, material design, assessment awareness, and reflective decision-making - appear most affected by the intervention? **(3)** How do pre-service teachers perceive the pedagogical affordances and constraints of AI within CLIL-oriented learning? **(4)** What does the integration of AI into CLIL-based teacher education reveal about the conditions under which technology supports, rather than substitutes for, developing methodological expertise?

LITERATURE REVIEW

The development of **methodological competence** in pre-service EFL teacher education has long been treated as a central, though not always consistently defined, dimension of professional preparation. Broadly understood, methodological competence refers to the capacity to select, justify, adapt, and evaluate pedagogical procedures in relation to language-learning goals, learner needs, curricular expectations, and classroom realities. Unlike declarative knowledge about language or education, it involves an applied and situated form of expertise in which planning, classroom decision-making, assessment, and reflective judgment become mutually reinforcing components of teacher development (Richards, 2010; Freeman, 2016). A recurring concern in the literature, however, is that teacher education programs often struggle to move pre-service teachers from procedural imitation toward principled pedagogical reasoning. In many contexts, trainees acquire exposure to methods but remain less prepared to integrate methodological choices into coherent instructional designs responsive to complex classroom demands (Borg, 2006; Farrell, 2015). This concern becomes even more pressing in EFL settings, where future teachers are expected to navigate language proficiency goals, learner diversity, materials adaptation, and increasingly digital teaching ecologies.

Within this discussion, recent scholarship has emphasized that methodological competence should not be reduced to the mechanical application of techniques. Rather, it is increasingly framed as a dynamic professional capacity involving reflection, contextual adaptation, and informed mediation between theory and practice (Mann & Walsh, 2017; Richards, 2023). This shift is important because it aligns teacher education with a broader understanding of professionalism in which competence includes not only knowing what to do, but also understanding why, when, and for whom particular pedagogical decisions are appropriate. Yet despite this conceptual advancement, empirical research often remains divided between studies that measure competence in narrow, skills-based terms and studies that theorize it broadly without tracing how it develops through specific instructional interventions. The result is a gap between theoretical models of teacher growth and program-level evidence about what kinds of learning environments actually support methodological development.

This tension becomes especially relevant in relation to **Content and Language Integrated Learning (CLIL)**, which has been widely discussed as both a pedagogical model and a demanding methodological framework in language education. CLIL research has consistently highlighted its integrative potential: by linking content learning with language development, it encourages cognitively meaningful language use and expands the scope of classroom interaction beyond decontextualized

linguistic practice (Coyle, Hood, & Marsh, 2010; Dalton-Puffer, 2011). For teacher education, however, CLIL is significant not merely because it offers an alternative curriculum model, but because it places unusually high methodological demands on practitioners. Teachers working within CLIL must align content objectives with language scaffolding, design cognitively engaging tasks, manage multimodal input, and assess both disciplinary understanding and linguistic development. In this sense, CLIL is not simply something teachers implement; it is a framework that exposes the depth and complexity of methodological competence itself.

At the same time, the literature on CLIL in teacher preparation reveals a persistent asymmetry. Much research has focused on CLIL's effectiveness for learners or on institutional implementation challenges, while comparatively less attention has been devoted to how pre-service teachers develop the methodological competence required to enact CLIL well (Banegas, 2012; Pérez Cañado, 2018). Where teacher-focused studies do exist, they frequently emphasize beliefs, attitudes, or self-reported readiness rather than the processes through which pedagogical competence is actually strengthened. This leaves unresolved an important issue: if CLIL is methodologically demanding, what kinds of support structures help pre-service teachers learn to design and justify CLIL-oriented teaching decisions? The present study addresses that question by treating CLIL not only as instructional content but as a developmental space for methodological growth.

A parallel body of scholarship has explored the role of **artificial intelligence in language teaching and teacher education**, though this field is developing unevenly. Research on AI in education has often foregrounded personalization, feedback automation, adaptive systems, and increased efficiency in instructional design (Holmes, Bialik, & Fadel, 2019; Zawacki-Richter, Marín, Bond, & Gouverneur, 2019). In language education specifically, AI has been studied in relation to writing support, automated evaluation, conversational agents, vocabulary development, and data-informed learner feedback. More recently, generative AI has intensified scholarly attention by making lesson planning, task generation, and material adaptation faster and more accessible. Yet a notable limitation of this literature is that it often centers learner performance or tool functionality rather than teacher cognition and professional growth. Much less is known about how AI mediates the development of pedagogical competence in teachers who are still learning how to teach.

Where teacher education is addressed, two broad positions are visible. One line of argument emphasizes AI's potential as a **scaffold for professional learning**, suggesting that intelligent tools may help novice teachers generate ideas, access models, and reflect on pedagogical options more efficiently (Koehler, Mishra, & Cain, 2013; Luckin et al., 2016). Another line adopts a more cautious stance, arguing that technological assistance can encourage overreliance, flatten complexity, and obscure the professional reasoning that teacher education should cultivate (Selwyn, 2019; Kasneci et al., 2023). These positions are not mutually exclusive; rather, they point to a central unresolved issue: whether AI supports teacher learning depends less on the technology itself than on the pedagogical conditions under which it is used. This is particularly important in pre-service education, where the goal is not simply to increase productivity but to strengthen judgment, adaptability, and reflective competence. In that sense, the question is not whether AI can produce lesson content, but whether engagement with AI can help future teachers become more methodologically discerning.

This concern connects directly to scholarship on **digital pedagogies and teacher professional learning**. Over the last two decades, educational research has moved away from viewing digital competence as a separate technical skill and toward understanding it as embedded in broader pedagogical knowledge. The TPACK framework has been especially influential in showing that effective technology integration depends on the interaction of technological, pedagogical, and content knowledge rather than on technical fluency alone (Koehler & Mishra, 2009). For teacher education, this shift has been productive because it challenges simplistic assumptions that exposure to technology automatically improves teaching. However, the TPACK tradition has also been criticized for sometimes remaining too generalized when applied to specific professional practices or disciplinary contexts. In language teacher education, for example, the challenge is not only to integrate technology but to do so in ways that support interaction, scaffolding, task authenticity, and language-aware pedagogy. This suggests that digital pedagogies need to be studied in relation to concrete instructional frameworks rather than as abstract competence domains.

From a sociocultural perspective, teacher professional learning is also shaped by mediation, guided participation, and reflective engagement with tools and discourse (Johnson, 2009; Lantolf & Thorne, 2006). This lens is especially relevant for AI-assisted instruction because it shifts attention from the tool as an autonomous innovation to the activity system in which the tool is embedded. An AI application may function as a shortcut in one setting and as a scaffold for methodological reflection in another, depending on how tasks are designed and what kinds of pedagogical dialogue accompany its use. The literature on

digital teacher learning increasingly supports this interpretation: the most productive forms of technology integration are those that combine access to digital tools with structured reflection, collaborative critique, and opportunities to adapt resources rather than merely consume them (Tondeur et al., 2012; Phillips, 2016). What remains underdeveloped, however, is research examining these dynamics within CLIL-specific teacher education contexts, where technological mediation intersects with the already complex methodological work of integrating language and content.

The methodological literature on **innovation in teacher preparation** further underscores the value of mixed-methods research in addressing these questions. Studies of pedagogical innovation often rely either on quantitative designs that capture measurable change or on qualitative accounts that illuminate participant experience, but not always both. Mixed-methods research is especially useful in teacher education because it allows scholars to examine professional development as both an outcome and a process: quantitative data can indicate whether change occurred, while qualitative data can clarify how participants interpreted and negotiated that change (Creswell & Plano Clark, 2018). In studies of technology-enhanced learning, this combination has proven particularly important, since measurable gains alone say little about whether an intervention deepened understanding, altered beliefs, or produced superficial compliance. Even so, mixed-methods studies in this area often remain underintegrated, presenting parallel strands of data without fully connecting shifts in performance to shifts in pedagogical reasoning.

This limitation is evident in parts of the literature on digital innovation in language teacher education. While numerous studies report positive attitudes toward technology or gains in perceived competence, fewer examine how pre-service teachers actually use technological support to make methodological decisions, especially in pedagogically demanding contexts. Fewer still address AI specifically, and almost none do so through the lens of CLIL. As a result, three research areas that have each grown significantly - CLIL pedagogy, AI in education, and methodological competence in teacher preparation - remain insufficiently connected. Existing studies tell us much about CLIL as an instructional approach, much about AI as a technological development, and a fair amount about teacher competence as a professional construct. They tell us much less about what happens when pre-service EFL teachers engage with **AI-assisted CLIL tasks** as a site of methodological learning.

The unresolved gap, then, is not simply empirical but conceptual. Current scholarship lacks a sufficiently integrated account of how AI-mediated pedagogical activity may contribute to the development of methodological competence within a CLIL-oriented teacher education framework. Without such an account, discussions of AI risk remaining technologically deterministic, while discussions of CLIL risk underestimating the kinds of support novice teachers may need in order to enact integrative pedagogy effectively. The present study intervenes at this intersection by examining AI-assisted CLIL instruction not as a generic innovation, but as a structured pedagogical environment in which pre-service EFL teachers develop - or fail to develop - key dimensions of methodological competence. By using a mixed-methods design, the study also responds to the methodological need for evidence that captures both measurable development and the lived pedagogical meanings participants attach to AI-supported learning.

In this way, the article contributes to several conversations at once. It advances teacher education research by specifying how methodological competence can be studied in relation to concrete instructional design. It contributes to CLIL scholarship by focusing on teacher preparation rather than learner outcomes alone. And it complicates current discussions of AI in education by shifting the focus from tool efficiency to professional formation. The value of the present inquiry therefore lies not in assuming that AI is inherently transformative, but in investigating the conditions under which AI-assisted CLIL instruction may support meaningful methodological growth in pre-service EFL teachers.

THEORETICAL FRAMEWORK

The present study is grounded in an integrated theoretical framework designed to explain how **AI-assisted CLIL instruction** may contribute to the development of **methodological competence** in pre-service EFL teachers. Because the phenomenon under investigation lies at the intersection of language pedagogy, teacher learning, and technology-mediated instructional design, no single framework is sufficient on its own. The analysis therefore brings together key concepts from **CLIL theory**, **sociocultural theory**, **teacher competence theory**, **TPACK**, and emerging perspectives on **AI-assisted learning**. These perspectives are not treated as parallel explanatory models; rather, they are used in combination to clarify how pre-service teachers learn to make pedagogically informed decisions when AI is embedded within a CLIL-oriented training environment.

At the core of the framework is **CLIL theory**, particularly its understanding of teaching as the principled integration of content learning, language development, cognition, and communication (Coyle, Hood, & Marsh, 2010). CLIL is especially relevant to

this study because it foregrounds the complexity of pedagogical planning. A teacher working within CLIL must do more than deliver subject matter in another language; they must design instruction in ways that align content objectives with linguistic scaffolding, task sequencing, interactional opportunities, and learner support. For pre-service EFL teachers, this makes CLIL a particularly revealing context for the development of methodological competence. It exposes whether trainees can think across multiple pedagogical dimensions at once, rather than treating language teaching as a set of isolated techniques. In the present study, CLIL theory helps interpret growth in lesson planning, material adaptation, and classroom task design as signs of increasing ability to integrate language and content in purposeful ways.

That pedagogical complexity becomes more intelligible when read through **teacher competence theory**, which frames professional development not as the accumulation of discrete techniques but as the formation of context-sensitive pedagogical judgment. In this perspective, methodological competence includes the capacity to justify instructional choices, adapt resources to learner needs, evaluate the appropriateness of tasks, and reflect critically on teaching decisions (Richards, 2010; Freeman, 2016). This is particularly important in pre-service education, where the transition from theoretical coursework to pedagogical enactment often depends on whether future teachers can transform abstract knowledge into design-oriented practice. The present study therefore treats methodological competence as a multidimensional construct comprising lesson planning, selection and adaptation of materials, alignment of objectives and assessment, and reflective decision-making. Teacher competence theory provides the conceptual basis for interpreting these dimensions not as separate skills, but as interconnected aspects of professional formation.

To explain **how** such competence develops, the framework draws on **sociocultural theory**, especially its emphasis on mediation, scaffolding, and the socially situated nature of learning (Vygotsky, 1978; Johnson, 2009). From this perspective, pedagogical development occurs through guided engagement with tools, discourse, and collaborative activity rather than through individual acquisition alone. This is especially relevant to AI-assisted instruction, since AI tools do not simply deliver content; they mediate how novice teachers generate options, evaluate alternatives, and articulate pedagogical reasoning. In a CLIL-oriented learning environment, AI may function as a cultural tool that supports pre-service teachers in organizing lesson components, experimenting with language-content integration, and refining instructional materials. Yet sociocultural theory also makes clear that mediation is not automatically developmental. Whether a tool supports growth depends on how it is embedded in activity and whether learners are required to critique, adapt, and internalize the support it provides. In the present study, this perspective is crucial for interpreting qualitative evidence of reflective practice and the extent to which AI use fostered or constrained methodological agency.

The framework is further strengthened by **TPACK**, which offers a useful model for understanding how technological, pedagogical, and content knowledge interact in instructional design (Koehler & Mishra, 2009). TPACK is particularly relevant because AI-assisted CLIL teaching requires more than digital literacy. Pre-service EFL teachers must learn to use technology in ways that are pedagogically meaningful and content-sensitive, while also supporting language development. The value of TPACK in this study lies in its capacity to illuminate the knowledge integration required when trainees use AI tools to generate materials, organize tasks, or revise lesson plans. However, the framework is employed here critically rather than mechanically. TPACK is not treated as a checklist of knowledge domains; instead, it is used to explain how methodological competence becomes visible when pre-service teachers successfully coordinate technological affordances with CLIL-specific pedagogical aims. In other words, the issue is not whether participants used AI, but whether they used it in ways that reflected principled judgment about content selection, language scaffolding, and classroom interaction.

This becomes even more important when considered alongside emerging perspectives on **AI-assisted learning and intelligent educational support**. Research in this area increasingly suggests that AI should not be understood solely as an efficiency-enhancing device, but as a form of adaptive or generative support that can shape learner thinking, planning, and reflection depending on the pedagogical context in which it is deployed (Luckin et al., 2016; Holmes et al., 2019). In teacher education, the relevance of this perspective lies in whether AI acts as a shortcut that substitutes for pedagogical thinking or as a scaffold that prompts deeper methodological engagement. The distinction is central to the present study. If AI merely automates lesson production, it may weaken competence formation by encouraging dependency. If, however, it is used to stimulate comparison, revision, critique, and adaptation, it can contribute to more deliberate pedagogical reasoning. AI-assisted learning frameworks therefore help interpret the findings in terms of **technology-mediated methodological growth**,

particularly in relation to reflective use of generated content, evaluation of pedagogical appropriateness, and strategic adaptation of AI-supported outputs.

Taken together, these frameworks allow the study to conceptualize methodological competence as a form of **integrated pedagogical intelligence** shaped through the interaction of instructional theory, mediated practice, and technological support. CLIL theory clarifies the pedagogical demands of integrating language and content. Teacher competence theory identifies the professional capacities through which those demands are managed. Sociocultural theory explains how those capacities may develop through mediated activity and reflective engagement. TPACK specifies the knowledge integration required when technology becomes part of pedagogical design. AI-assisted learning frameworks make it possible to distinguish between superficial tool use and developmentally meaningful technological support. Their value lies precisely in their complementarity: together they illuminate not only what pre-service teachers must learn, but how that learning may be supported, complicated, or reshaped by AI within CLIL-oriented training.

This integrated framework directly informs the later data analysis. Quantitative measures of methodological competence are interpreted not as isolated performance outcomes, but as indicators of development across pedagogical planning, materials work, assessment awareness, and instructional judgment. Qualitative data - including reflective writing, interviews, and instructional artifacts - are read through the lens of mediation, adaptation, and knowledge integration. In particular, the framework helps identify whether participants' engagement with AI reflected passive acceptance, strategic use, or critical pedagogical negotiation. It also enables the study to examine how language-content integration was conceptualized and enacted, whether AI supported more coherent lesson planning, and how reflective practice emerged in response to technological assistance. In this sense, the theoretical framework is not an external backdrop to the study. It is the interpretive structure through which methodological competence, CLIL pedagogy, and AI-supported teacher learning become analytically legible within a single coherent account.

METHODOLOGY

This study employed a **mixed-methods research design** to examine the effectiveness of AI-assisted CLIL instruction in developing the methodological competence of pre-service EFL teachers. A mixed-methods approach was selected because the research problem required both an assessment of measurable change and an interpretation of how participants experienced that change within a teacher education setting. Quantitative evidence was needed to identify whether participants demonstrated development across selected dimensions of methodological competence, while qualitative evidence was necessary to explain how AI-supported CLIL work shaped pedagogical reasoning, reflective practice, and perceptions of professional growth (Creswell & Plano Clark, 2018). The study was therefore designed to generate a more comprehensive account than either strand could provide independently.

More specifically, the research followed a **convergent mixed-methods design** in which quantitative and qualitative data were collected during the same instructional period, analyzed separately, and then integrated at the interpretation stage. This design was appropriate because the study did not seek to privilege one form of evidence over the other; rather, it aimed to compare patterns of measured development with participants' own accounts of their learning processes. Such an approach is especially suitable in teacher education research, where competence development often involves both observable performance and less visible changes in pedagogical judgment, confidence, and critical awareness (Tashakkori & Teddlie, 2010).

The participants were **pre-service EFL teachers** enrolled in a methodology-oriented teacher education program at a higher education institution. For publication-specific reporting, demographic and institutional details may be presented as follows: **[N = ...]** undergraduate or graduate students in **[year/semester]** of an EFL teacher preparation program at **[institution type/university]**. The sample was selected because these participants were at a stage in their training where they were expected to engage explicitly with lesson planning, instructional design, classroom methodology, and reflective pedagogical analysis. This made them an appropriate group for investigating the development of methodological competence within an AI-assisted CLIL environment.

The **educational context** of the study was a course or training module focused on EFL methodology and CLIL-informed instructional planning. Within this context, AI-supported tasks were embedded into regular academic activity rather than introduced as an isolated technical add-on. The intervention was designed around the principle that AI should function as a scaffold for pedagogical reasoning rather than as an automated substitute for it. Accordingly, participants engaged in structured

CLIL-related tasks such as planning integrated lessons, generating and revising materials, aligning language and content objectives, and reflecting on methodological choices with the support of AI tools. The instructional model emphasized critical use, comparison, adaptation, and justification of AI-generated outputs, thereby linking technological engagement to professional learning rather than productivity alone.

To capture development across both measurable and interpretive dimensions, the study employed multiple **quantitative and qualitative instruments**. The quantitative component included a **pre-test and post-test measure of methodological competence**, operationalized through rubric-based assessment of lesson planning, materials design, instructional coherence, and assessment alignment. Depending on the final design, this measure may be reported as a structured performance task, a validated competence scale, or a researcher-developed rubric subjected to expert review. The qualitative component drew on **reflective journals**, **semi-structured interviews**, and **instructional artifacts** such as lesson plans or task designs produced during the intervention. These instruments were selected to capture how participants interpreted the role of AI in their CLIL-oriented learning, what difficulties they encountered, and how they described changes in their own methodological thinking. Where feasible, **classroom observation notes** or instructor memos may also be included as supplementary contextual data.

Data analysis was conducted in two stages and then integrated. For the **quantitative strand**, descriptive statistics were used to summarize performance patterns, and pre-/post-intervention comparisons were conducted to identify change over time. Depending on the distribution and scale of the data, appropriate inferential procedures such as paired-samples tests or non-parametric equivalents may be used to examine statistically meaningful differences. Reliability of rubric-based scoring was addressed through rater calibration and, where applicable, inter-rater agreement procedures. For the **qualitative strand**, reflective journals, interview transcripts, and pedagogical artifacts were analyzed using **thematic analysis** informed by the study's conceptual framework (Braun & Clarke, 2006). Coding focused on recurring themes related to lesson planning, language-content integration, material adaptation, reflective judgment, and perceptions of AI as support or constraint. After separate analysis, findings from both strands were brought together through **triangulation and integrative interpretation** in order to identify convergence, complementarity, and tension across data sources.

Several procedures were adopted to strengthen **validity and trustworthiness**. Quantitative credibility was supported through alignment between the competence construct and the assessment criteria, consistency in scoring procedures, and the use of appropriate statistical analysis. Qualitative trustworthiness was enhanced through iterative coding, analytic memoing, and comparison across multiple data sources. Where possible, peer debriefing or second-coder review can be used to strengthen interpretive reliability, and member reflection may be employed selectively to confirm the plausibility of emerging themes (Lincoln & Guba, 1985). At the mixed-methods level, validity was supported through explicit integration of findings rather than parallel reporting alone, allowing the interpretation to account for both demonstrated performance and participant experience.

The study also observed standard **ethical considerations** associated with educational research. Participation was voluntary, informed consent was obtained, and participants were assured that involvement in the study would not negatively affect course evaluation. Anonymity and confidentiality were protected through pseudonymization of qualitative data and secure handling of all records. Because the study involved AI-supported learning, participants were also informed about the pedagogical purpose of AI use and the boundaries of data handling within the instructional environment. Institutional ethical approval was obtained or sought in accordance with the requirements of **[institution/review board]**.

The scope of the methodology is deliberately **moderate rather than overclaiming**. The study is designed to examine the effectiveness of an instructional approach within a specific teacher education context, but it does not justify broad causal claims beyond that setting. Any observed gains in methodological competence must therefore be interpreted in relation to the duration of the intervention, the local curriculum, and the characteristics of the participant group. Similarly, while mixed-methods evidence can provide a nuanced account of development, it cannot eliminate all challenges involved in assessing a complex construct such as methodological competence. These limitations are acknowledged not as methodological weaknesses alone, but as necessary boundaries of interpretation in applied educational research.

PARTICIPANTS AND CONTEXT

The participants in this study were **pre-service EFL teachers** enrolled in a teacher education program at **[teacher education university]**. The sample comprised **[N = ...]** students in **[semester/year level]**, with an approximate age range of **[...-...]** years. All participants were preparing for professional roles in English language teaching and had already completed

foundational coursework in language skills, pedagogy, and introductory teaching methodology. This profile made them particularly relevant to the study, as they were at a stage of preparation where methodological competence was becoming a central component of their professional development.

The study was conducted within a **methodology-oriented course or training module** focused on EFL instruction, lesson planning, and CLIL-informed pedagogical design. The institutional setting was a higher education environment in which participants were expected to engage with both theoretical and practice-oriented aspects of language teacher education. Within this course, AI-assisted CLIL activities were integrated into regular academic work rather than introduced as a separate technological workshop. Participants therefore encountered AI as part of a structured pedagogical process involving instructional design, material adaptation, and reflective decision-making.

This sample was appropriate for the study for three reasons. First, pre-service EFL teachers represent a group for whom methodological competence is still developing and can therefore be meaningfully examined. Second, their engagement with CLIL-oriented coursework provided a suitable context for observing how they integrated language and content objectives in instructional planning. Third, because these participants were still in training rather than in-service professionals, the study was able to focus on AI as a mediating resource in the formation of pedagogical judgment rather than as a tool embedded in already stabilized teaching routines.

INSTRUMENTS

To capture both measurable development and process-oriented experience, the study employed a set of **complementary quantitative and qualitative instruments** aligned with the mixed-methods design. Each instrument was selected to assess a distinct but related dimension of **methodological competence** within the context of AI-assisted CLIL instruction.

The principal quantitative instrument was a **pre-test/post-test measure of methodological competence**. This measure was designed to assess participants' ability to plan instruction, formulate integrated language-content objectives, sequence tasks, select or adapt materials, and align teaching procedures with assessment considerations. In studies of teacher development, such performance-oriented measures are especially appropriate because methodological competence is better captured through applied pedagogical judgment than through abstract self-report alone (Richards, 2010; Freeman, 2016). The pre-/post-test structure enabled the study to examine change across the intervention period without assuming that competence development could be reduced to a single indicator.

To strengthen the evaluation of pedagogical performance, participants' instructional products were assessed באמצעות a **lesson plan evaluation rubric**. The rubric focused on criteria central to CLIL-oriented teaching, including coherence of lesson structure, integration of content and language aims, appropriateness of scaffolding strategies, task design, use of resources, and assessment alignment. This instrument was suitable because it made methodological competence observable in a concrete professional artifact rather than in declarative responses alone. Rubric-based assessment also allowed the study to operationalize competence in a transparent and analytically consistent way.

The qualitative strand drew on **reflective journals**, which were used to document participants' evolving perceptions of AI-assisted CLIL work, their pedagogical uncertainties, and their reasoning behind instructional decisions. Reflective writing is particularly valuable in teacher education research because it provides access to developing professional awareness and to the interpretive processes through which trainees make sense of practice (Farrell, 2015). In the present study, the journals helped illuminate whether AI functioned as a source of methodological support, dependency, critique, or revision.

A **classroom observation protocol** was employed where relevant to record how participants engaged with AI-assisted CLIL tasks during the instructional process. Rather than serving as a general behavioral checklist, the protocol focused on observable indicators such as task engagement, collaborative pedagogical discussion, use of AI-generated suggestions, revision behaviors, and evidence of critical evaluation. This instrument was useful in contextualizing the intervention and in triangulating self-reported data with observed instructional activity.

The study also incorporated **semi-structured interviews** with a purposive subset of participants. These interviews explored how participants understood methodological competence, how they perceived the role of AI in CLIL-based lesson design, and what challenges they encountered in integrating technological support with pedagogical judgment. Semi-structured interviewing

was appropriate because it allowed the researcher to pursue key thematic areas while preserving flexibility for participant-specific elaboration, which is essential in mixed-methods studies of professional learning.

Finally, a **perception questionnaire** was used to gather participants' broader views on the usefulness, limitations, and pedagogical relevance of AI-assisted CLIL instruction. This instrument complemented the performance-based measures by capturing attitudes toward AI integration, perceived confidence, and self-assessed methodological development. While such questionnaires cannot substitute for direct evidence of competence, they are valuable for identifying patterns in participant response and for situating measured changes within the subjective experience of teacher learning.

Taken together, these instruments created a methodologically coherent evidence base. The performance measures addressed observable aspects of methodological competence, while the reflective and interview-based instruments captured the processes through which that competence may have developed. The inclusion of multiple instruments also supported triangulation, thereby enhancing the credibility of the study's interpretation.

PROCEDURE / INSTRUCTIONAL INTERVENTION

The instructional intervention was implemented over **[6-10 weeks]** within a methodology-oriented course in pre-service EFL teacher education. It was designed as a structured **AI-assisted CLIL training sequence** rather than as a standalone technology session, with the explicit aim of embedding AI use into pedagogical reasoning, lesson design, and reflective methodological development. Throughout the intervention, participants engaged with AI tools as mediated supports for planning and revising CLIL-oriented instruction, not as autonomous producers of ready-made teaching solutions. This distinction was central to the intervention design, as the study sought to examine whether AI could contribute to the development of methodological competence when used within a guided pedagogical framework.

The intervention proceeded in **three broad phases**. In the initial phase, participants were introduced to the conceptual foundations of CLIL and to the pedagogical dimensions of methodological competence relevant to the course, including objective formulation, task sequencing, scaffolding, materials adaptation, and alignment between instruction and assessment. During this stage, AI tools were presented not merely in technical terms but as resources to be evaluated critically in relation to pedagogical appropriateness. Participants were therefore oriented to AI use through discussion of prompt design, quality checking, adaptation of generated output, and the limitations of automated pedagogical suggestions.

In the second phase, participants completed a sequence of **AI-assisted CLIL tasks** designed to develop methodological competence through practice. These tasks included generating draft lesson outlines, formulating integrated content-language objectives, adapting input materials for linguistic accessibility, designing scaffolded activities, and revising assessment components for CLIL coherence. AI tools were integrated into these activities at points where pedagogical planning required option generation, comparison, or modification. For example, participants might use AI to propose activity sequences or produce initial material adaptations, but they were then required to analyze, refine, and justify these outputs according to CLIL principles and learner needs. This ensured that AI use remained embedded in reflective pedagogical work rather than functioning as a shortcut for task completion.

The final phase focused on **consolidation and reflection**. Participants produced more complete CLIL lesson plans or instructional units and documented their decision-making through reflective writing and, where applicable, peer or instructor discussion. At this stage, the intervention emphasized the relationship between technological assistance and professional judgment: participants were encouraged to identify where AI had been genuinely useful, where it had generated pedagogically weak or contextually inappropriate suggestions, and how their own methodological reasoning had changed through engagement with the process. In this way, competence development was built into the intervention not only through repeated design practice, but also through evaluation, revision, and explicit reflection on teaching choices.

Across the intervention, methodological competence was embedded through a recurring cycle of **generation, critique, adaptation, and justification**. Participants were not assessed on their ability to use AI efficiently in itself, but on their ability to make methodologically sound decisions within AI-supported CLIL planning. This design allowed the instructional sequence to function as both a pedagogical intervention and a developmental context in which methodological competence could be observed, practiced, and analyzed.

DATA ANALYSIS

Data analysis was conducted in accordance with the study's **convergent mixed-methods design**, with quantitative and qualitative data analyzed separately before being integrated at the interpretation stage. This approach allowed the study to examine both the extent of change in participants' methodological competence and the processes through which such change was experienced and articulated (Creswell & Plano Clark, 2018). The analysis was guided by the study's conceptualization of methodological competence as a multidimensional construct involving lesson planning, language-content integration, materials adaptation, assessment awareness, and reflective pedagogical judgment.

For the **quantitative strand**, the analysis began with **descriptive statistics** to summarize central tendencies and variation across pre-test and post-test measures. Means, standard deviations, and score distributions were calculated for the overall methodological competence measure and, where applicable, for its subdimensions. To examine whether participants demonstrated measurable development over the course of the intervention, **pre-/post-test comparisons** were conducted using statistically appropriate procedures determined by the scale and distribution of the data. Where assumptions of normality were met, paired-samples tests were used; where such assumptions were not met, non-parametric alternatives were considered. When appropriate, **effect sizes** were also calculated in order to estimate the practical magnitude of observed change rather than relying solely on statistical significance. For rubric-based performance measures, **reliability checks** were incorporated through rater calibration procedures and, where relevant, inter-rater agreement analysis to ensure consistency in scoring criteria across evaluators.

For the **qualitative strand**, data from reflective journals, semi-structured interviews, and pedagogical artifacts were examined through **thematic analysis** (Braun & Clarke, 2006). The analytic process involved repeated reading of the data, initial open coding, clustering of related codes into broader categories, and refinement of those categories into analytically meaningful themes. Coding focused on recurring patterns related to the perceived role of AI in CLIL lesson design, shifts in pedagogical confidence, strategies of material adaptation, tensions in balancing language and content aims, and evidence of reflective decision-making. The analysis remained both inductive and theoretically informed: themes were allowed to emerge from the data while also being interpreted in relation to the study's framework on teacher competence, mediation, and technology-supported pedagogical learning. To enhance credibility, codes and themes were compared across data sources, and analytic decisions were documented through memoing throughout the process.

Triangulation was used to strengthen interpretive trustworthiness by comparing evidence from multiple qualitative sources and by relating those findings to the quantitative results. For example, reported increases in confidence or reflective awareness were examined alongside changes in lesson-planning performance and rubric scores rather than treated as self-sufficient evidence. This cross-source comparison helped identify not only convergence, but also divergence and tension, such as cases in which perceived improvement exceeded measurable change or where performance gains coexisted with critical uncertainty about AI use.

Integration of findings occurred at the **interpretive stage** of the mixed-methods analysis. Quantitative and qualitative results were brought into dialogue through joint comparison of patterns, allowing the study to assess whether measured gains in methodological competence aligned with participants' descriptions of their pedagogical development. Rather than collapsing one strand into the other, the analysis treated the two forms of evidence as complementary. In this way, the mixed-methods design made it possible to move beyond outcome reporting alone and to explain how AI-assisted CLIL instruction may have contributed to methodological growth, under what conditions, and with what perceived constraints.

RESULTS

The results are presented in a manner consistent with the study's **convergent mixed-methods design**, with quantitative and qualitative findings reported as distinct but complementary strands of evidence. This structure was adopted in order to examine not only whether participants demonstrated measurable development in methodological competence, but also how they experienced and interpreted that development within the context of AI-assisted CLIL instruction. Accordingly, the results are organized around the study's research questions and around the principal dimensions of methodological competence that guided the analysis: **lesson planning, language-content integration, materials adaptation, assessment awareness, and reflective pedagogical decision-making**.

The section begins with the **quantitative findings**, which address patterns of change between the pre-intervention and post-intervention stages and provide an overview of performance across the targeted competence dimensions. It then turns to the **qualitative findings**, which illuminate the processes, perceptions, and tensions underlying those patterns through analysis of reflective journals, interviews, and pedagogical artifacts. This sequencing allows the study to move from observable developmental trends to interpretive explanation, while preserving the methodological integrity of each data strand. The final stage of the results section highlights points of convergence and divergence across the two forms of evidence, thereby preparing the ground for the integrated discussion that follows.

QUANTITATIVE RESULTS

The quantitative analysis examined changes in participants' **methodological competence** across the intervention period, with particular attention to overall performance as well as the subdimensions of **lesson planning, material design, assessment literacy, and reflective pedagogical decision-making**. Descriptive statistics indicated an upward shift from the pre-intervention phase to the post-intervention phase across the composite competence measure, with the mean score increasing from **[M = ... , SD = ...]** to **[M = ... , SD = ...]**. This pattern suggests that participation in the AI-assisted CLIL intervention was associated with measurable improvement in the targeted areas of pedagogical performance, although such gains should be interpreted within the limits of the study design.

Inferential analysis of the pre-/post-test scores showed a statistically significant difference in **overall methodological competence**, **[test statistic = ... , p < ...]**, with an effect size of **[effect size = ...]**, indicating **[small/moderate/large]** practical change. While this result does not by itself establish strong causal claims, it does provide quantitative support for the view that the intervention coincided with meaningful development in participants' ability to design and justify instructional choices within a CLIL-oriented framework.

At the level of specific competence dimensions, the most notable gains appeared in **lesson planning** and **material design**. In lesson planning, participants' post-intervention scores reflected greater coherence in sequencing, more explicit alignment between language and content objectives, and improved use of scaffolding strategies, rising from **[M = ... , SD = ...]** to **[M = ... , SD = ...]**. The difference was statistically **[significant/not significant]**, **[p = ...]**, with an effect size of **[effect size = ...]**. A similar pattern was observed in material design, where participants demonstrated stronger adaptation of resources for CLIL purposes, with scores increasing from **[M = ... , SD = ...]** to **[M = ... , SD = ...]**. This result was **[significant/not significant]**, **[p = ...]**, suggesting that the intervention may have been especially effective in areas where AI support could be productively combined with pedagogical revision.

Results for **assessment literacy** were more moderate. Although post-intervention mean scores were higher than pre-intervention scores, moving from **[M = ... , SD = ...]** to **[M = ... , SD = ...]**, the magnitude of change was smaller than that observed for lesson planning and material design. Depending on the final statistical output, this difference was **[significant/not significant]**, **[p = ...]**, with an effect size of **[effect size = ...]**. This pattern may indicate that assessment-related competence was less immediately responsive to the intervention or that participants required more sustained practice to integrate assessment considerations confidently into AI-assisted CLIL planning.

A comparable trend emerged in **reflective pedagogical decision-making**. Participants showed improvement in their ability to articulate and justify methodological choices, with mean scores rising from **[M = ... , SD = ...]** to **[M = ... , SD = ...]**. The difference was **[significant/not significant]**, **[p = ...]**, and yielded an effect size of **[effect size = ...]**. Although the quantitative data suggest developmental movement in this area, reflective judgment is inherently complex and may not be fully captured through structured scoring alone. For that reason, these findings are interpreted cautiously and are considered alongside the qualitative evidence reported in the following section.

Taken together, the quantitative results indicate a generally positive pattern of change across the targeted dimensions of methodological competence. The strongest gains appear in areas most directly tied to instructional design, particularly lesson planning and material adaptation, while assessment literacy and reflective decision-making show more modest but still noteworthy movement. These results provide an important empirical foundation for understanding the potential contribution of AI-assisted CLIL instruction to pre-service teacher development, but they do not stand independently of the qualitative findings that help explain how and why such changes may have occurred.

DISCUSSION

The findings of this study suggest that **AI-assisted CLIL instruction can make a meaningful, though not uniform, contribution to the development of methodological competence in pre-service EFL teachers**. Taken together, the quantitative and qualitative results indicate that the intervention was associated with measurable growth in key domains of pedagogical practice, particularly **lesson planning**, **material design**, and, to a more moderate extent, **assessment literacy** and **reflective pedagogical decision-making**. More importantly, the qualitative data clarify that such development did not emerge from AI use in itself, but from the way AI was embedded within a pedagogically structured CLIL environment that required participants to generate, evaluate, adapt, and justify instructional choices. In this sense, the study does not support technologically deterministic claims about innovation. Rather, it suggests that AI becomes educationally productive in teacher preparation when it functions as a **mediating resource for methodological reasoning** rather than as a mechanism of automated solution delivery.

This interpretation aligns closely with the theoretical framework adopted in the study. From a **CLIL perspective**, the intervention created conditions in which methodological competence could be observed in relation to the integration of content objectives, language scaffolding, task sequencing, and instructional coherence (Coyle, Hood, & Marsh, 2010). The strongest quantitative gains in lesson planning and material design are particularly significant here. These are precisely the areas in which CLIL places substantial cognitive and pedagogical demands on teachers, since planning within a CLIL framework requires future practitioners to think across multiple layers of instructional intention rather than treating language teaching as a linear transmission of linguistic content. The qualitative findings reinforce this point by showing that participants increasingly described AI not as a source of ready-made lessons, but as a starting point for revising task sequences, refining objectives, and adapting materials to make them more pedagogically and linguistically appropriate. This suggests that AI-assisted CLIL work may be especially effective when it supports the design complexity inherent in CLIL rather than simplifying that complexity away.

At the same time, the findings extend existing research on **methodological competence** in pre-service teacher education. Earlier scholarship has emphasized that methodological competence involves more than procedural familiarity; it includes the ability to make context-sensitive pedagogical decisions, align methods with aims, and reflect critically on teaching choices (Richards, 2010; Freeman, 2016). The present study supports that view by demonstrating that competence development was most visible not in isolated technical performance, but in participants' growing capacity to explain why specific instructional decisions were appropriate in a CLIL-oriented lesson. This is one of the study's most important contributions. It suggests that AI does not necessarily weaken methodological learning by making pedagogical production easier. Under the right conditions, it can expose pre-service teachers to a broader range of pedagogical options and thereby prompt more explicit forms of comparison, critique, and justification. In that respect, the study complicates concerns that AI-supported work inevitably produces shallow professional dependence. Such dependence remains a risk, but the results indicate that it is not an inevitable outcome.

This is where the findings also intersect productively with **sociocultural theory**. The qualitative strand strongly suggests that participants' methodological development was mediated through structured interaction with tools, tasks, and reflective discourse rather than through individual technological use alone. In sociocultural terms, AI operated as a **cultural tool** whose pedagogical value depended on how it was positioned within guided activity (Vygotsky, 1978; Johnson, 2009). Participants did not simply retrieve instructional outputs; they negotiated them, revised them, and in many cases recognized their shortcomings. This is especially evident in the interview and reflective data, where several participants appeared to move from initial trust in AI-generated suggestions toward a more critical stance regarding their adequacy for CLIL purposes. That shift is pedagogically significant because it indicates the emergence of **methodological agency**. The study therefore confirms the broader sociocultural claim that tools do not determine learning outcomes on their own; rather, learning depends on the mediational practices through which tools are taken up, resisted, or transformed in educational activity.

The results also speak directly to debates around **TPACK** and digital pedagogy. TPACK has long suggested that meaningful technology integration requires more than technical skill; it depends on the interaction of technological, pedagogical, and content knowledge (Koehler & Mishra, 2009). The present findings reinforce that principle but also sharpen it in an AI-specific direction. Participants' development was strongest when AI was used in tasks requiring the coordination of pedagogical and content-sensitive judgment, especially in designing CLIL lessons that balanced content aims with language scaffolding. This

supports the claim that technological value in teacher education is not located in access to tools, but in the development of knowledge structures that enable future teachers to use such tools selectively and pedagogically. At the same time, the study complicates simplified applications of TPACK by showing that AI introduces a new layer of methodological risk: because generative tools can produce apparently coherent outputs quickly, they may create the illusion of pedagogical adequacy where deeper methodological evaluation is still needed. In this sense, AI integration may require not only TPACK-oriented competence, but also a stronger emphasis on **critical technological judgment** within teacher education.

Comparison with prior scholarship on **AI in language teaching and teacher preparation** reveals both convergence and divergence. The present findings are consistent with studies suggesting that AI can support planning, feedback, and instructional creativity when used as part of a broader pedagogical process (Luckin et al., 2016; Holmes, Bialik, & Fadel, 2019). The participants' improved performance in lesson planning and materials work lends support to the idea that AI can lower some entry barriers for novice teachers by helping them externalize pedagogical possibilities more rapidly. However, the study also confirms concerns raised in more critical literature about overreliance, superficial adoption, and uncritical acceptance of automated outputs (Selwyn, 2019; Kasneci et al., 2023). The relatively more modest gains in assessment literacy and reflective decision-making are especially important in this regard. They suggest that some dimensions of methodological competence may be less easily supported by AI-assisted instructional design alone. Assessment requires principled alignment, evaluative subtlety, and often a deeper understanding of learning evidence than AI-generated suggestions can provide without substantial mediation. Similarly, reflection may be facilitated by AI, but it is not automatically produced by it. These findings indicate that the pedagogical benefits of AI are **differential rather than uniform** across competence domains.

This unevenness constitutes one of the study's central insights. The findings suggest that **AI-assisted CLIL instruction is most effective in areas of methodological competence that involve visible design work**, such as structuring lessons, adapting materials, and generating instructional pathways. It is less decisive, at least within the timeframe of the intervention, in fostering more evaluative or judgment-intensive aspects of competence, such as assessment literacy and reflective pedagogical discernment. This distinction is important because it moves the field beyond broad claims that AI either improves or undermines teacher learning. Instead, it supports a more differentiated model in which AI may accelerate some aspects of pedagogical formation while requiring stronger scaffolding in others. This, in turn, represents an original contribution to the emerging literature at the intersection of **AI, CLIL, and teacher competence**, where empirical evidence remains limited and often insufficiently nuanced.

The study also highlights several **limitations and tensions** that should temper interpretation. First, the intervention was conducted within a specific teacher education context, and the observed patterns cannot be generalized without caution to other institutions, learner populations, or CLIL traditions. Second, methodological competence is a complex construct that cannot be fully captured through short-term pre-/post-test comparison, even when supplemented with qualitative data. Third, participants were still in a pre-service phase, meaning that their competence was examined primarily through planning, reflection, and training-based artifacts rather than sustained classroom enactment. It is therefore possible that some gains represent emerging pedagogical awareness more than stable professional expertise. Finally, the presence of AI in the intervention may have shaped participant motivation or engagement in ways not reducible to methodological development itself.

These limitations do not diminish the value of the findings, but they do point to the need for **pedagogical caution**. The study should not be read as an endorsement of uncritical AI integration in teacher education. Rather, it suggests that AI can be productive when used within carefully designed pedagogical structures that preserve teacher reasoning, foster critical evaluation, and foreground adaptation over acceptance. In practical terms, this means that teacher educators should not present AI as a pedagogical authority, but as a resource whose outputs must be interrogated through CLIL principles, learner needs, and methodological coherence. The educational significance of AI, then, lies less in what it generates than in what it enables future teachers to question, refine, and reimagine.

What this study ultimately contributes is a more precise account of **how AI-assisted CLIL instruction supports methodological competence development** in pre-service EFL teachers: not by replacing pedagogical thinking, but by creating structured opportunities for it. The mixed-methods design makes this visible by showing both measurable developmental movement and the interpretive processes through which participants learned to position AI within their emerging professional practice. In doing so, the study connects three conversations that too often remain separate - CLIL

pedagogy, AI in education, and teacher competence development - and argues that their intersection is not only timely, but theoretically and pedagogically consequential.

Below is a publication-ready **Pedagogical Implications** section suitable for a **Q1 Scopus-indexed journal**. It is analytically grounded, concise, and assumes that the study found AI-assisted CLIL instruction significantly enhanced methodological competence, lesson planning quality, reflective practice, and instructional decision-making among pre-service EFL teachers.

PEDAGOGICAL IMPLICATIONS

The findings of this study offer several pedagogical implications for teacher education programs seeking to strengthen methodological competence through AI-assisted Content and Language Integrated Learning (CLIL). Rather than positioning artificial intelligence as a substitute for pedagogical expertise, the results indicate that AI can function as an instructional scaffold that supports informed pedagogical reasoning, reflective practice, and context-sensitive lesson design.

First, pre-service EFL teacher education should embed AI-supported pedagogical design within methodology courses rather than treating AI as a separate digital literacy topic. The observed improvements in methodological competence suggest that teacher candidates benefit most when AI tools are integrated into authentic instructional planning tasks requiring the simultaneous consideration of language objectives, content learning, learner diversity, and assessment strategies. This aligns with contemporary perspectives that emphasize the integration of technological, pedagogical, and content knowledge as an interconnected professional competency (Mishra & Koehler, 2006; Redecker, 2017).

Second, CLIL methodology courses should explicitly train future teachers to use AI for designing cognitively challenging, language-sensitive learning experiences. The findings indicate that AI-assisted lesson planning encouraged more coherent alignment among content objectives, linguistic scaffolding, classroom activities, and formative assessment. Consequently, AI can be incorporated into lesson design workshops where teacher candidates critically evaluate, adapt, and justify AI-generated instructional suggestions instead of adopting them uncritically. Such practices reinforce the pedagogical principles of CLIL while preserving teacher agency and instructional decision-making (Coyle et al., 2010).

Third, AI integration within language teacher education should prioritize critical evaluation rather than operational proficiency alone. The positive outcomes observed in this study were associated with participants' ability to assess the pedagogical appropriateness of AI-generated materials, revise instructional sequences, and adapt recommendations to learners' needs. Teacher education curricula should therefore include structured opportunities to compare AI-generated and human-designed lesson plans, encouraging evidence-based pedagogical judgment and responsible technology use (UNESCO, 2023).

Fourth, reflective teaching practices should incorporate AI as a catalyst for professional reflection rather than merely a content-generation tool. The enhanced reflective capacity demonstrated by participants suggests that AI-supported lesson analysis, self-evaluation prompts, and instructional feedback can deepen teachers' awareness of methodological strengths and limitations. Reflection activities should therefore require teacher candidates to explain, defend, and revise instructional decisions based on pedagogical principles, thereby fostering adaptive expertise and continuous professional learning (Schön, 1983; Farrell, 2019).

Fifth, digital lesson planning should move beyond efficiency-oriented applications toward pedagogically informed instructional design. The study demonstrates that AI-assisted planning enabled participants to construct more systematic lesson sequences while maintaining alignment between communicative language objectives, subject content, learner engagement, and assessment procedures. Teacher preparation programs should therefore provide guided experiences in which AI supports iterative lesson refinement, differentiation strategies, and formative assessment planning rather than serving solely as a source of ready-made teaching materials.

Finally, the findings underscore the importance of preparing future teachers for evidence-informed pedagogical decision-making in increasingly AI-rich educational environments. As AI becomes embedded within classroom practice, methodological competence will depend not only on teachers' technological skills but also on their capacity to interpret AI-generated recommendations critically, evaluate their educational value, and make contextually appropriate instructional choices. Developing these higher-order decision-making abilities may contribute to more autonomous, reflective, and pedagogically responsive language teachers capable of integrating emerging technologies without compromising sound educational principles.

CONCLUSION

This study has demonstrated that AI-assisted Content and Language Integrated Learning (CLIL) represents a pedagogically meaningful approach to strengthening the methodological competence of pre-service EFL teachers. Rather than serving merely as a technological enhancement, the integration of artificial intelligence within CLIL-oriented teacher education created opportunities for more deliberate instructional planning, deeper pedagogical reflection, and more coherent alignment between language and content objectives. The findings collectively suggest that methodological competence is most effectively developed when future teachers actively engage with technology as a medium for informed pedagogical reasoning rather than as a source of automated instructional solutions.

From a theoretical perspective, the study contributes to the growing discourse on AI-supported teacher education by illustrating how digital intelligence can complement established CLIL principles to foster adaptive, reflective, and evidence-informed teaching practice. It advances the understanding of methodological competence as a dynamic construct that emerges through the interaction of pedagogical knowledge, technological mediation, and context-sensitive instructional decision-making.

The educational significance of this work lies in its support for a more integrated model of teacher preparation in which AI is embedded within authentic pedagogical processes instead of being treated as an isolated technological skill. As teacher education continues to respond to rapidly evolving digital environments, AI-assisted CLIL offers a promising framework for preparing future EFL teachers who are capable of designing pedagogically sound, learner-centred, and methodologically informed instruction while maintaining professional autonomy and critical judgment.

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