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Teacher Pedagogical Competencies for Content and Language Integrated Learning in Mathematics within English as a Foreign Language Context: A Systematic Review

Noraida Md Idrus
Faculty of Education, The National University of Malaysia
43600 Bangi, Selangor, Malaysia; Corresponding Author: noraida.mdidrus@gmail.com
Nurfaradilla Mohamad Nasri
Faculty of Education, The National University of Malaysia
43600 Bangi, Selangor, Malaysia; Email: nurfaradilla@ukm.edu.my
Muhammad Sofwan Mahmud
Faculty of Education, The National University of Malaysia
43600 Bangi, Selangor, Malaysia; Email: sofwanmahmud@ukm.edu.my

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Abstract
This systematic review investigates the pedagogical competencies required for effective Content and Language Integrated Learning in mathematics classrooms with particular attention to EFL contexts. The study aims to identify the competencies teachers need, the instructional innovations that support content language integration, and the ways teacher-mediated assessment practices shape instructional outcomes. Addressing ongoing concerns with regard to teacher preparedness for multilingual mathematics education, the review highlights the significance of aligning mathematical reasoning with academic language development. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol, a structured search of Scopus and Web of Science (WoS) identified 22 peer-reviewed empirical studies published between January 2023 and November 2025. Thematic synthesis revealed three key areas: teacher professional competence and institutional capacity-building; pedagogical innovations and instructional design in CLIL and English-Medium Instruction classrooms; and teacher-mediated instructional outcomes and assessment practices. The findings indicate that effective CLIL mathematics teaching depends on sustained professional learning, strong institutional support and language-responsive instructional design. At the same time, assessment practices are crucial for aligning content mastery with language development. Overall, this review contributes a consolidated evidence base for competency-oriented teacher education and curriculum planning in multilingual mathematics education. The review concludes with recommendations for future research to examine long-term professional learning models and context-sensitive pedagogical frameworks that can better support teachers in diverse multilingual settings.

***Keywords*:** Content and language integrated learning, instructional strategies, mathematics education, pedagogical competence, teacher professional development
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Introduction

The rapid expansion of Content and Language Integrated Learning (CLIL) in mathematics education has not been supported by a clear and consolidated understanding of the pedagogical competencies required for its effective implementation. Furthermore, existing studies remain fragmented and frequently address language integration in broad educational contexts (Kurniawati et al., 2025; Querol-Julián, 2025; Villabona & Cenoz, 2022). This, leaves limited and inconsistent evidence on how teachers successfully combine mathematical reasoning with academic language development in multilingual and English as a Foreign Language (EFL) classrooms. Consequently, this lack of focused synthesis creates uncertainty for teacher education, curriculum design and policy planning, signaling a critical need for a systematic review dedicated to pedagogical competencies in CLIL mathematics settings.

CLIL has emerged as a powerful pedagogical approach in which subject content and language instruction are delivered simultaneously, fostering both disciplinary mastery and bilingual competence. In mathematics education, CLIL offers unique opportunities when learners engage with mathematical concepts through a non-native or additional language. It can deepen conceptual understanding and enhance their academic language repertoire. Within the EFL context, CLIL provides structured exposure to discipline-specific English. This exposure supports the simultaneous development of mathematical reasoning and academic English proficiency. Likewise, the growing global adoption of CLIL in Science, Technology, Engineering and Mathematics (STEM) classrooms underlines its pedagogical relevance, especially in multilingual educational contexts where educators must navigate complex affordances related to cognitive load, language scaffolding and content delivery. The professional competence of teachers in such settings is therefore critical. They require strong mathematical content knowledge and pedagogical agility, as well as linguistic awareness, to support tasks, manage discourse and assess students in dual-focused classrooms.

Empirical research on language-responsive mathematics teaching has demonstrated that enhancing teachers' expertise in identifying linguistic demands can significantly support students' learning of both mathematics and the target language. Design-based research observed that professional development for language-responsive mathematics teaching strengthened teachers' capacity to discern mathematically relevant language functions and integrate them into classroom talk (Jiménez-Silva et al., 2025). Meanwhile, systematic reviews in CLIL contexts reveal persistent deficits in teacher training. While pedagogical and linguistic competencies are frequently addressed, other domains, such as interpersonal, reflective, and collaborative competencies, remain underrepresented (Scherzinger & Brahm, 2023). Furthermore, theoretical and practical models of CLIL teacher professional development highlight the multifaceted, context-dependent nature of competence for CLIL practitioners (Lo, 2020). Nonetheless, despite the expanding literature on CLIL, most studies focus on general pedagogical strategies or language-support practices across disciplines. In contrast, the specific pedagogical competencies required for CLIL implementation in mathematics classrooms remain insufficiently synthesized. In particular, researchers have paid relatively little attention to how teacher competencies are defined, translated into practice and strengthened through teacher education and professional development in mathematics-focused CLIL settings.

The significance of this study lies in addressing fragmentation by synthesizing empirical research on teachers' pedagogical competencies in CLIL mathematics education. By focusing on how professional capacity, instructional design and teacher-mediated assessment practices interact, the study contributes to both EFL education and mathematics education scholarship. The review also provides insights that can inform teacher education programs, professional development initiatives and institutional policy aimed at strengthening multilingual mathematics instruction.

Accordingly, the main aim of this Systematic Literature Review (SLR) is to synthesize empirical evidence on the pedagogical competencies required for effective CLIL implementation in mathematics education within the EFL context. To achieve this aim, the study pursues the following objectives:

1. To identify the key pedagogical competencies required by mathematics teachers to implement CLIL effectively.
2. To examine the instructional innovations that facilitate the integration of content and language in CLIL and English-Medium Instruction (EMI) mathematics classrooms.
3. To analyse how teacher-mediated assessment practices shape instructional outcomes in CLIL mathematics classrooms.

Therefore, the three research questions developed using the Population, Interest, Context (PICo) (Lockwood et al., 2015) format are as follows:

1. What pedagogical competencies do mathematics teachers need to enact CLIL effectively?
2. Which instructional innovations support content-language integration in CLIL and EMI mathematics classrooms?
3. How do teacher-mediated assessment practices influence instructional outcomes in CLIL mathematics classrooms?

Literature Review

Research on pedagogical competencies in CLIL mathematics education demonstrates increasing diversification of instructional demands, particularly with the inclusion of learners who face linguistic or cognitive challenges. This trend is especially relevant in EFL mathematics classrooms, where teachers must integrate mathematical reasoning with academic English development to support multilingual learners' participation and conceptual understanding (Ayob & Hamada, 2024; Misme & Yawiloeng, 2023; Snizhko, 2025). A framework for integrating content, cognition and language is proposed to support learners, emphasising structured pedagogical planning grounded in communicative competence and pluriliteracies principles (Afzal Awan & Sipra, 2018; Hussain, 2022; Ní Ríordáin & Neville, 2026). Broader investigations confirm that CLIL requires teachers to negotiate disciplinary expertise, linguistic awareness and pedagogical flexibility as part of evolving professional identities as demonstrated in university STEM contexts (Montgomery et al., 2025). Parallel studies highlight that CLIL mathematics instruction often combines hands-on, interdisciplinary practices such as Maker Education, STEM integration and project-based learning. This, suggests that multimodal environments enhance language development and conceptual reasoning when guided by competent teachers (Bairy & Inamdar, 2024; Imamyartha et al., 2024; Lege et al., 2025). Collectively, these studies indicate a trend toward

competency frameworks that merge cognitive scaffolding, linguistic mediation and inquiry-driven mathematics learning.

Classroom studies indicate that effective CLIL mathematics teaching involves clear explanations, consistent language support and careful attention to students' use of academic discourse. Analyses of secondary classrooms demonstrate clear integration of content and language through sustained instructional clarity, signaling the pedagogical precision required of CLIL teachers (Mahan et al., 2021). Cognitive load research reveals that learner expertise interacts strongly with instructional design, underscoring the necessity for teachers to differentiate linguistic scaffolding based on students' proficiency profiles (Jiang et al., 2023). Additional investigations of bilingual mathematical problem solving suggest that early learners' performance improves as language proficiency increases, highlighting the importance of teacher strategies that link semantic structures to mathematical reasoning (Ester Mariñoso et al., 2021). However, despite promising outcomes, including gains in mathematical achievement reported in longitudinal CLIL studies (Surmont et al., 2016), substantial gaps remain. This is particularly evident in the availability of validated tools for assessing pedagogical competencies, such as a structured self-assessment rubric for CLIL STEM contexts (Luelmo del Castillo et al., 2025). Previous studies on language-focused professional development in mathematics highlight ongoing gaps between the intended curriculum and what teachers actually implement. This, in turn, underscores the need for long-term, context-responsive teacher learning models (Hajer & Norén, 2017).

Despite increasing research on CLIL and EFL, two critical gaps remain. First, existing studies predominantly examine general CLIL pedagogy rather than competencies specific to mathematics teaching. Second, previous reviews rarely integrate teacher professional development, instructional design and assessment practices into a unified competency perspective. These gaps limit the field's ability to inform coherent teacher education and policy development for multilingual mathematics classrooms.

Method

This SLR was structured around the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines introduced by Page et al. (2021). These guidelines offer a clear and methodical pathway for locating, filtering and consolidating research evidence, helping minimize potential bias and strengthening the overall trustworthiness of the review process. The search strategy focused on two well-established academic databases, Scopus and Web of Science (WoS). The selection of Scopus and WoS was based on their recognition as two leading databases for peer-reviewed academic publications. Both apply strict journal selection and indexing standards that help ensure high research quality, sound methodology, and reliable citation records. Using these databases also reduces the risk of including predatory or low-impact sources, thereby strengthening the credibility of the systematic review. Following the PRISMA logic, the review progressed through four interconnected phases: identifying potential studies, screening them against predetermined criteria, determining their eligibility and finally extracting and analyzing the data. Together, these stages provided a systematic, transparent approach to organizing the literature and evaluating its contributions. Refer to Figure 1.

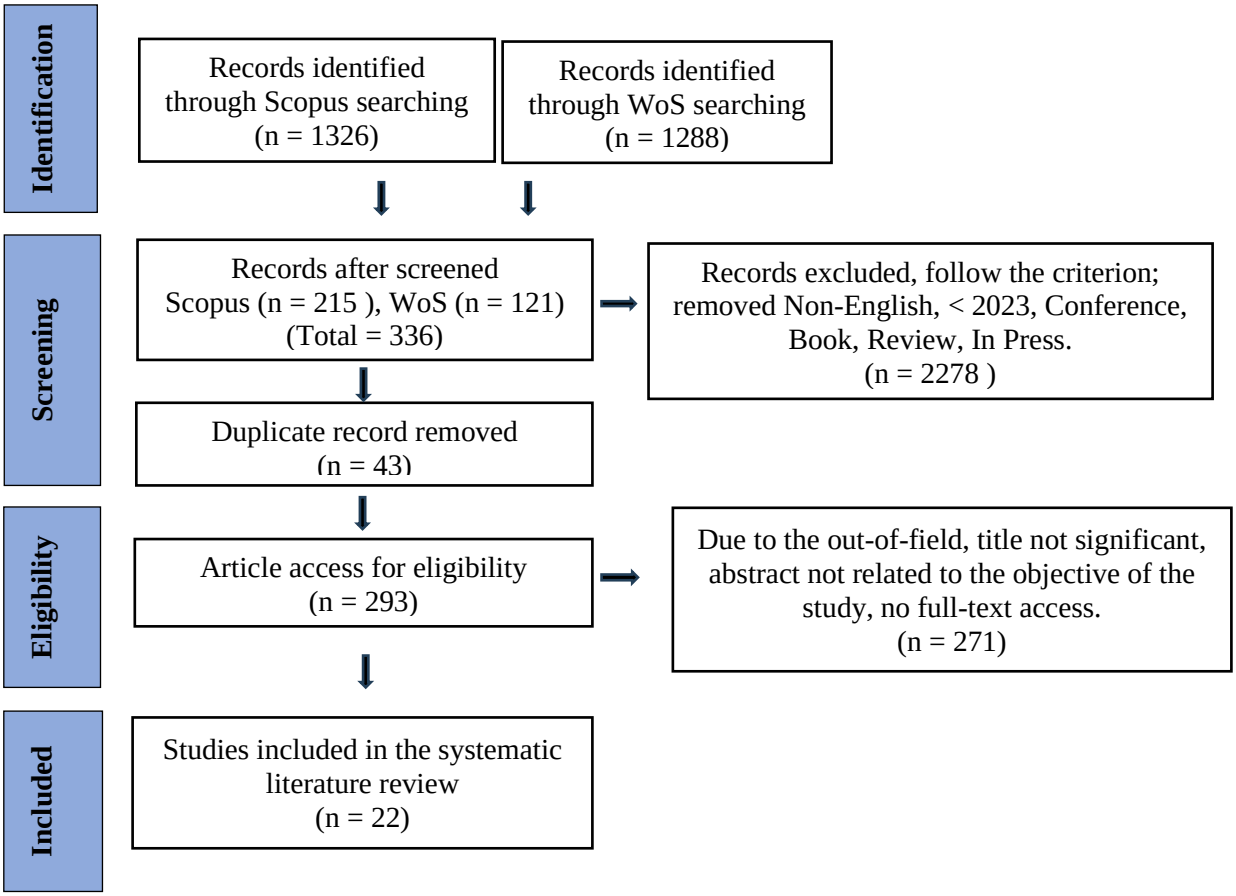


Figure 1. Flow diagram of the proposed searching study

In this review, the term "participants" refers to the peer-reviewed journal articles that formed the core dataset for analysis. The initial search across two major scholarly databases yielded a total of 2614 records, 1326 from Scopus and 1288 from WoS. These records were then processed through a structured screening procedure to remove duplicate entries and exclude studies that fell outside the scope of the review or did not meet the required quality benchmarks. Application of the inclusion and exclusion criteria resulted in 293 unique articles. A final check of thematic relevance and full-text availability narrowed the selection to 22 studies for qualitative analysis.

Research Instruments

To maintain a systematic and replicable review process, the study employed several established tools. A detailed search string was developed using Boolean operators to ensure that all relevant publications were captured across the selected databases. The strategy incorporated a set of core terms ("CLIL", "Content and Language Integrated Learning", "Mathematics Education", "Mathematics Instructions", "Pedagogies", "Strategies" and "Teachers' Professional Development") to enhance the precision and breadth of the search results. The review limited its selection of studies to articles published in Open Access journals. This criterion was applied to ensure full and

unrestricted access to the complete texts of all identified studies, which is essential for rigorous qualitative synthesis and accurate data extraction. The exact search strings used for each database are presented in Appendix A (Table A1).

To determine which studies qualified for the final analysis, predefined selection criteria were established before the screening stage. These criteria took into account the publication year, the language of the work, the type of document, and its overall relevance to the review's focus. A comprehensive outline of the inclusion and exclusion conditions is provided in Table 1.

Table 1. *The selection criterion in searching*

CRITERION	INCLUSION	EXCLUSION
Language	English	Non-English
Timeline	2023 – 2025	< 2023
Literature Type	Journal (Article)	Conference, Book, Review
Publication Stage	Final	In Press

To uphold the quality of the review and limit potential bias, all included studies were examined using a six-item evaluation framework adapted from Abouzahra et al. (2020). The criteria (QA1–QA6) addressed key dimensions of scholarly rigor, including: (1) clarity of the study's purpose, (2) relevance and practical applicability, (3) methodological robustness, (4) precision in defining key concepts, (5) depth of comparative analysis, and (6) acknowledgment of the study's own limitations. Each item was scored using a three-tier scale: "Yes" (1 point) when the criterion was fully met, "Partly" (0.5 points) when it addressed with minor shortcomings, and "No" (0 points) when the study did not meet the criterion. Two reviewers independently evaluated the articles and discussed any disagreements to reach a consensus, ensuring consistency and objectivity. This structured appraisal process served as a safeguard against evaluator bias and strengthened the overall reliability of the review.

Research Procedures

The review adhered to the four sequential phases outlined in the PRISMA framework: identification, screening, eligibility and inclusion. In the identification phase, we conducted extensive database searches using predefined search strings, and all searches were completed in November 2025. During screening, duplicate records were removed, and the titles and abstracts were reviewed to exclude studies that did not meet the inclusion criteria. In the eligibility phase, full-text versions of the remaining studies were retrieved and examined in detail to determine their alignment with the focus on teacher pedagogical competencies in CLIL mathematics classrooms. Articles were excluded at this stage if they lacked empirical substance, theoretical relevance or accessible full-text documentation. In the final stage, 22 studies that satisfied all criteria were confirmed and prepared for systematic data extraction. The resulting evidence was organized into thematic categories that shaped the subsequent analysis and interpretation presented in this review.

Results

This review combined findings from 22 peer-reviewed studies published between 1 January 2023 and 30 November 2025 that explored CLIL in mathematics, primarily within EFL settings. Using a thematic analysis approach, three overarching themes were derived: (1) teacher professional competence and institutional capacity-building; (2) pedagogical innovations and instructional design in CLIL/EMI classrooms; and (3) teacher-mediated instructional outcomes and assessment practices. The primary studies (PS) for each thematic domain, along with their detailed quality scores are presented in Appendix B (Table B1).

Teacher Professional Competence and Institutional Capacity-Building

Teacher assessment literacy and validated instruments emerge as priority areas for operationalising teacher competence. Xin and Lo (2025) reported the development and validation of a CLIL Teacher Assessment Literacy Inventory that delineates assessment approaches, mediating factors and confidence levels after expert review and pilot testing. Luelmo del Castillo et al. (2025) similarly developed and validated a self-assessment rubric CLIL-Science, Technology, Engineering, Arts, and Mathematics-Self-assessment Tool (CLIL-STEAM-SAT) using Delphi and Nominal Group procedures, offering psychometrically oriented evidence for measuring teacher practices. Studies by De La Cal et al. (2023) and Polyakova and O'Callaghan (2023) presented that co-teaching and post-graduate training improve teachers' pedagogical skills and confidence. This, indicates that validated assessment tools combined with structured professional development, can support accurate needs identification and targeted skill improvement.

Professional development approaches and implementation formats vary in effectiveness depending on their design and context. Diaz-Martin (2023) noted that video-based training enhances pre-service teachers' understanding of CLIL and reflective awareness of practice. De La Cal et al. (2023) demonstrated that co-teaching in STEM+CLIL contexts improves pedagogical design skills and confidence among pre-service cohorts. Polyakova and O'Callaghan (2023) suggested that competence development correlates with linguistic awareness and communal support in post-graduate settings. Taken together, the reviewed studies suggest that diverse professional development pathways such as video-based reflection, collaborative co-teaching and post-graduate training modules play a significant role in strengthening teachers' pedagogical competence in CLIL settings. When structured around reflective activities and peer support mechanisms, these initiatives contribute to improved instructional alignment, greater assessment literacy and stronger teacher self-efficacy in integrating mathematical content with language objectives.

Green-Eneix and de Costa (2025) documented professional vulnerability when top-down EMI/CLIL policy alters institutional expectations, linking ideological mismatch to identity disruption and pedagogical strain. Belobrovy (2023) underscored the need for capacity-building measures that increase lecturers' ownership and practical salience for curricular reform to persist. Ruiz-Cecilia et al. (2025) and Szczesniak (2024) identified workload, insufficient training and limited institutional coordination as barriers that undermine teacher well-being and program viability. These findings imply that competence frameworks and professional development initiatives require aligned

institutional policies, resourcing, and psychosocial supports to be translated into sustained classroom practice.

Pedagogical Innovations and Instructional Design in CLIL/EMI Classrooms

Recent studies foreground the role of technological and multimodal affordances in mediating content and language integration. Pérez et al. (2025) reported that immersive virtual reality (VR) environments can elevate learners' engagement, self-efficacy and retention when vocabulary and domain concepts are taught within CLIL scenarios. Tai (2024) asserted that using iPads helps teachers support translanguaging and multimodal learning in English-medium mathematics, with technology acting as a bridge to guide students' mathematical communication. Complementary evidence from Budiarta et al. (2023) indicated that online micro-teaching formats, when carefully structured with dual-focus activities can produce measurable gains in both content and language achievement.

A parallel cluster of studies advances inquiry-based and integrative pedagogies as viable frameworks for CLIL instruction. Imamyartha et al. (2024) aligned a STEAM-informed 6E's cycle (engage, explore, explain, engineer, enrich, evaluate) with CLIL's pluriliteracies. This implies, showing that structured inquiry stimulates multidimensional learning, positive academic emotions and sustained engagement. Teresa and Fields (2023) presented Phenomenon-Based Learning (PhBL) as a cross-curricular inquiry model that cultivates 21st-century skills and student agency, useful for linking authentic problems to language development in STEM contexts. Guzmán-Alcón and Lorenzo (2025) argued that disciplinary literacies must be rethought in multilingual settings so that task design and materials intentionally support both content mastery and language practices.

Language-sensitive pedagogical choices, such as translation, translanguaging, and disciplinary literacy scaffolds, appear as contested yet productive strategies in the studies. Gaballo (2023) revisited the role of translation within CLIL, proposing collaborative translation activities as a constructivist means to connect prior linguistic repertoires with subject learning. Tai (2024) and Guzmán-Alcón and Lorenzo (2025) further indicated that strategic use of multiple semiotic resources (language switching, visuals, vocabulary framing) supports students' movement from concrete examples to abstract reasoning. Pérez et al. (2025) highlighted that multimodal tools, such as VR can reduce cognitive load for less proficient learners by providing concrete, embodied support for understanding specialized vocabulary.

Methodological strengths and recurrent gaps appear across the studies. Empirical diversity-experimental VR studies (Pérez et al., 2025), multimodal conversation analysis (Tai, 2024), mixed-method micro-teaching research (Budiarta et al., 2023) and Delphi-informed rubric work (Imamyartha et al., 2024) enable triangulation of how instructional designs operate. However, several studies report common limitations including short intervention periods, context-specific samples and a lack of long-term evidence on transfer and retention. Guzmán-Alcón and Lorenzo (2025) and Imamyartha et al. (2024) advocated for clearer operationalization of disciplinary literacies and standardized measures while Pérez et al. (2025) underscored to the need for broader testing of immersive tools across proficiency levels.

Teacher-Mediated Instructional Outcomes and Assessment Practices

Effective assessment practice and teacher assessment literacy are foregrounded as essential mediators of instructional outcomes in CLIL mathematics settings. Xin and Lo (2025) developed and validated an inventory specifically aimed at CLIL teachers' assessment literacy. The study reported that instruments which address assessment approaches, mediating contextual factors and teacher confidence can inform diagnostic and formative practice. Complementary attention to disciplinary task design is reported by Guzmán-Alcón and Lorenzo (2025), who note variability in how disciplinary literacies are integrated and argue that clearer task and material design are necessary to align assessment with disciplinary demands. Evidence from national classroom studies (Bauer-Marschallinger et al., 2023) corroborated the need for teacher capacity in assessment design, demonstrating that pedagogical practices and language scaffolding vary widely and thus influence the validity of classroom assessments.

Teacher enactment shapes affective and performance outcomes, with robust quantitative evidence indicating complex subject-specific effects. Wunberg et al. (2024) used propensity score matching and structural equation modeling to illustrate that CLIL participation is associated with higher English self-concepts, while leaving math self-concepts generally unaffected. Similar patterns are evident in related large-scale work (Wunberg et al., 2024), which emphasizes the need to account for pre-existing differences when attributing outcomes to instructional models. Contextual reports from classroom and school studies (Bauer-Marschallinger et al., 2023; Guzmán-Alcón & Lorenzo, 2025) suggested that teacher strategies for language scaffolding and disciplinary literacy development modulate these effects. This, implies that student self-concept outcomes are mediated by teacher pedagogical choices and assessment practices.

Inclusion and assessment fairness receive particular attention where teachers adapt instruction for diverse learners. Ní Ríordáin et al. (2024) documented that language-responsive mathematics lessons improve engagement and participation among Additional Educational Need (AEN) learners. However, adapted summative assessments may under-capture full mathematical competence due to of persistent cognitive-linguistic demands. This finding resonates with calls for more reliable assessment tools in CLIL contexts (Xin & Lo, 2025) and with national studies (Bauer-Marschallinger et al., 2023) that highlight inconsistencies in assessment and support provision. The combined evidence highlights pedagogical adaptations that can increase access, yet summative instruments require careful redesign to validly reflect discipline-specific knowledge for linguistically diverse students.

Across the studies, methodological strengths include instrument validation and rigorous causal controls. At the same time, recurring gaps remain: a paucity of longitudinal tracking of teacher practice to student outcomes, limited cross-context benchmarking of assessment instruments, and scarce integration of teacher well-being metrics into assessment studies. A coherent research agenda would prioritize validated teacher assessment measures (Xin & Lo, 2025), standardized operationalization of disciplinary literacies (Guzmán-Alcón & Lorenzo, 2025) and longitudinal mixed-methods designs linking teacher enactment, assessment validity and student affective and cognitive outcomes (Bauer-Marschallinger et al., 2023; Ní Ríordáin et al., 2024; Wunberg et al., 2024).

Discussion

This review examined three core areas: the pedagogical competencies for implementing CLIL (RQ1), instructional innovations to support content and language integration (RQ2), and teacher-mediated assessment practices that shape instructional outcomes (RQ3). The findings revealed that effective CLIL mathematics teaching requires a combination of pedagogical, linguistic and assessment-related competencies supported by sustained professional development and institutional capacity-building. Furthermore, the growing use of instructional innovations such as translanguaging strategies, technology-enhanced learning and interdisciplinary approaches that strengthen content language integration. Additionally, teacher-mediated assessment practices play a central role in shaping instructional outcomes by aligning mathematical understanding with academic language development. Together, these insights emphasize that successful CLIL mathematics implementation depends on the coherent interaction between teacher expertise, innovative pedagogy and assessment alignment.

Across the selected studies, the first theme underscores that professional competence in CLIL mathematics teaching is inseparable from institutional capacity. Studies such as those by Belobrovy (2023), Diaz-Martin (2023) and Polyakova and O'Callaghan (2023) highlighted that teachers develop stronger dual-domain proficiency when supported through structured professional development, collaborative learning and coherent curriculum guidelines. This finding aligns with previous evidence by Zhang and Deris (2023), indicating that participation in comprehensive training programs contributes positively to teachers' competence in implementing CLIL. Where institutions offer fragmented training or insufficient mentorship, teachers demonstrate weaker instructional coherence and lower confidence in mediating mathematical content through an additional language. These studies collectively justify selecting the first theme, as institutional structures are consistently positioned as antecedents of individual teacher competence. Notably, pedagogical growth depends on teachers' intrinsic motivation and their access to consistent training, shared pedagogical models and departmental alignment. Thematically, this demonstrates that competence-building operates at two levels: the professional skills teachers acquire and the systemic opportunities that enable those skills to be enacted. This insight contributes to broader debates on CLIL sustainability, indicating that teacher quality is inseparable from institutional readiness. Consequently, capacity-building emerges as a foundational area for future CLIL mathematics research, particularly in relation to longitudinal teacher development and cross-departmental collaboration.

The second theme, Pedagogical Innovations and Instructional Design was selected based on multiple studies that emphasize teachers' roles as instructional designers capable of adapting content, language and multimodal resources to the needs of multilingual mathematics learners. Research by Tai (2024), Imamyartha et al. (2024) and De La Cal et al. (2023) revealed that effective CLIL mathematics instruction depends on teachers' ability to apply pedagogical innovations such as translanguaging spaces, STEM-integrated approaches, technology-mediated support and multimodal scaffolding. These innovations facilitate comprehension of mathematical concepts and create more accessible linguistic pathways. The prevalence of these findings supports the selection of the second theme, as instructional innovations consistently serve as the primary means by

which teachers apply pedagogical competencies. Moreover, these innovations address methodological gaps in earlier CLIL models that assumed linear alignment between content and language objectives. Instead, the reviewed studies establish that high-performing CLIL mathematics teachers engage in flexible pedagogical design such as reconfiguring tasks, discourse structures and learning environments to respond to learners' diverse language proficiencies. This aligns with broader trends in multilingual education, indicating a shift towards adaptive design, pragmatic translanguaging and integrated STEM-CLIL pedagogies. This observation is consistent with the work of Sapawi and Yusoff (2025) which highlights a shift toward learner-centred pedagogy, particularly through personalised instructional practices.

The third theme focuses on teacher-mediated outcomes and assessment practices. Several studies highlight that effective CLIL mathematics teaching should be assessed by both its instructional delivery and its impact onlearner outcomes such as engagement, self-concept, content mastery, and language development. Studies by Wunberg et al. (2024), Nha (2025), and Luelmo del Castillo et al. (2025) provided evidence that teachers' assessment literacy, monitoring strategies and feedback practices shape learners' academic trajectories in CLIL contexts. These studies consistently highlight the centrality of assessment, formal evaluation, and continuous formative assessment embedded in classroom interaction. The findings demonstrate that teacher-led assessment practices mediate learners' experience of the dual demands of mathematics and language learning. This supports selecting the third theme, as it highlights the role of assessment in ensuring instructional alignment and fairness in linguistically complex mathematics classrooms. Furthermore, the research suggests that inadequate assessment literacy leads to misalignment between language difficulty and mathematical cognitive load, thereby affecting student confidence and progression. These insights underscore the need for more refined assessment frameworks tailored for CLIL mathematics.

Collectively, these findings generate several implications for practice. First, educational institutions should prioritize coherent, continuous professional development tailored to the linguistic and cognitive complexities of CLIL mathematics. General CLIL training is insufficient. Domain-specific programs that integrate mathematical discourse awareness, pedagogy for multilingual learners and contextualised instructional design are essential. Second, teacher preparation programs should foreground innovative pedagogical models, including translanguaging, STEAM-CLIL integration and blended learning environments, equipping future educators with adaptable tools for diverse classrooms. Third, assessment literacy must be strengthened through training that integrates language-sensitive evaluation and content-focused diagnostic practices. Finally, institutional alignment, including policies, curriculum, and administrative leadership, is critical for sustaining teacher competence and avoiding fragmentation across departments or programs.

The limitations of this review are mainly related to the inclusion of only English-language publications issued between 1 January 2023 and 30 November 2025, which may constrain the depth and breadth of interpretation. In addition, differences in reporting conventions across journals could influence the extent to which certain pedagogical competencies are emphasized. Thus, future research should address gaps in long-term teacher development in CLIL mathematics, the impact of institutional leadership styles

on pedagogical transformation, and the development of validated assessment tools for dual-focused learning. Longitudinal and mixed-methods approaches would provide deeper insights into the interactions between teacher competence, instructional design and learner outcomes. Despite these limitations, this review provides a structured understanding of the competencies required for CLIL mathematics teaching and underscores the critical alignment between professional, pedagogical, and assessment-related domains for high-quality implementation.

Conclusion

This systematic review clarifies the pedagogical competencies required for effective CLIL in mathematics within EFL education. The findings indicate that successful implementation depends on strong pedagogical knowledge, language-responsive teaching skills and sustained institutional support that enables teachers to manage the dual demands of content and language learning in multilingual classrooms. Several contributions emerge from this review. The analysis clarifies how teacher competencies function across interconnected professional, instructional and evaluative domains, offering a consolidated perspective often missing from previous literature. It also emphasizes that capacity-building must be sustained through targeted professional development, coherent departmental support and refined assessment tools that reflect the linguistic demands of mathematics learning. Future research should explore long-term competence development, institutional mechanisms that sustain pedagogical transformation and the validation of assessment instruments suited for dual-focused mathematics instruction. Nevertheless, this review strengthens the understanding of the competencies required for high-quality CLIL mathematics teaching. It highlights the significance of aligning pedagogical, institutional, and assessment practices to support mathematics learning in a multilingual educational system.

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About the Authors:

Noraida Md Idrus is a PhD candidate in Curriculum and Pedagogy at the National University of Malaysia. Her research focuses on developing the curriculum model of financial education in teaching mathematics for secondary school. Email: noraida.mdidrus@gmail.com
ORCID: https://orcid.org/0009-0000-5477-6136

Nurfaradilla Mohamad Nasri is an Associate Professor of Curriculum and Pedagogy at the National University of Malaysia. Her main research interest relates to the development of

culturally responsive instruction, teachers' professional development, self-directed learning and sustainable learning. Email: nurfaradilla@ukm.edu.my
ORCID: https://orcid.org/0000-0001-8572-3838

Muhammad Sofwan Mahmud is an Associate Professor of Mathematics Education at the National University of Malaysia. His research interests include qualitative research, mathematical thinking, problem-solving and mathematics education. Email: sofwanmahmud@ukm.edu.my
ORCID: https://orcid.org/0000-0002-0504-4622

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Appendices
Appendix A
Search Strings for Databases

Table A1. *Search strings for databases*

DATABASE	SEARCH STRING
SCOPUS	TITLE-ABS-KEY ((CLIL OR "Content and Language Integrated Learning" OR "Content Language Integrated Learning") AND (("Mathematics Education" OR "Mathematics Instructions" OR "Mathematics Classroom" OR "Mathematics Learning" OR "Mathematics Teaching" OR "Mathematics Teaching and Learning") OR (Pedagogies OR "Pedagogical Competencies" OR Strategies OR Approaches) OR ("Teacher* Professional Development" OR "Teacher* Training"))) AND (LIMIT-TO (EXACTKEYWORD , "Clil") OR LIMIT-TO (EXACTKEYWORD , "Content And Language Integrated Learning (clil)") OR LIMIT-TO (EXACTKEYWORD , "Content And Language Integrated Learning") OR LIMIT-TO (EXACTKEYWORD , "Teacher Training")) AND (LIMIT-TO (SUBJAREA , "SOCI")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (OA , "all")) Date of Access: 30 November 2025
WoS	(CLIL OR "Content and Language Integrated Learning" OR "Content Language Integrated Learning") AND (("Mathematics Education" OR "Mathematics Instructions" OR "Mathematics Classroom" OR "Mathematics Learning" OR "Mathematics Teaching" OR "Mathematics Teaching and Learning") OR (Pedagogies OR "Pedagogical Competencies" OR Strategies OR Approaches) OR ("Teacher* Professional Development" OR "Teacher* Training")) (Topic) and Open Access and 2023 or 2024 or 2025 (Publication Years) and

	Article (Document Types) and English (Languages) and All Open Access (Open Access) and Article (Document Types) and English (Languages) Date of Access: 30 November 2025

Appendix B
Performance of Quality Assessment for the Primary Studies

Table B1. *Performance of quality assessment for the primary studies*

Primary Study (PS)	Theme	Scopus	WoS	QA 1	QA 2	QA 3	QA 4	QA 5	QA 6	Total Mark	Percentage (%)
PS1 Xin & Lo (2025) Developing the CLIL Teacher Assessment Literacy Inventory	1	/	/	1	1	1	1	0.5	0	4.5	75.0%
PS2 Pérez et al. (2025) Effects of VR on Students' Engagement & Self-Efficacy	2	/	/	1	1	1	0.5	0	0	3.5	58.3%
PS3 Guzmán-Alcón & Lorenzo (2025) Disciplinary Literacies in Multilingual Europe	2	/	/	1	1	1	1	0.5	0	4.5	75.0%
PS4 Rocha (2025) Language Assistant Programs & CLIL	1	/	/	1	1	1	1	0.5	0	4.5	75.0%
PS5 Nha (2025) Content and Language Teaching in EMI	1	/	/	1	1	1	0.5	0.5	0	4.0	66.7%
PS6 Green-Eneix & de Costa (2025) Professional Vulnerability in Adopting a CLIL Pedagogy	1	/	/	1	1	1	0.5	0	0	3.5	58.3%
PS7 Ruiz-Cecilia et al. (2025) Factors that promote teacher well-being among CLIL secondary teachers	1	/	/	1	1	1	0.5	0	0	3.5	58.3%
PS8 Luelmo del Castillo et al. (2025) Design and validation of a self-assessment tool for STE(A)M teachers in CLIL contexts	1	/	/	1	1	1	1	0.5	0	4.5	75.0%
PS9 Wunberg et al. (2024) CLIL effects on academic self-concepts: Positive effects in English but detrimental effects in math?	3	/	/	1	1	1	1	0.5	0	4.5	75.0%
PS10 Tai (2024) Classroom interactional competence in EMI mathematics classroom: A technology-mediated translanguaging space	2	/	/	1	1	1	1	0.5	0	4.5	75.0%
PS11 (Ní Ríordáin et al. (2024) Language-responsive mathematics teaching and	3	/	/	1	1	1	1	0.5	0.5	5.0	83.3%

Primary Study (PS)	Theme	Scopus	WoS	QA 1	QA 2	QA 3	QA 4	QA 5	QA 6	Total Mark	Percentage (%)
AEN learners in a CLIL context											
PS12 Szczesniak (2024) Teachers' concerns in CLIL primary schools	1	/	/	1	1	1	0.5	0.5	0	4.0	66.7%
PS13 Imamyartha et al. (2024) STEAM pedagogy to broaden CLIL pedagogy	2	/	/	1	1	1	1	0.5	0	4.5	75.0%
PS14 De La Cal et al. (2023) Co-teaching for STEAM+CLIL pre-service training	1	/	/	1	1	1	0.5	1	0	4.5	75.0%
PS15 Teresa & Fields (2023) Phenomenon-Based Learning in STEM with CLIL	2	/	/	1	1	0.5	1	0	0	3.5	58.3%
PS16 Diaz-Martin (2023) Professional Development of Pre-Service Language Teachers in CLIL	1	/	/	1	1	0.5	0.5	0	0	3.0	50%
PS17 Gaballo (2023) Translation in CLIL: Mission Impossible?	2	/	/	1	1	0.5	1	0.5	0	4.0	66.7%
PS18 Polyakova & O'callaghan (2023) Post-graduate Training in CLIL Competence Development	1	/	/	1	1	1	0.5	0.5	0	4.0	66.7%
PS19 Budiarta et al. (2023) CLIL in Online Micro-Teaching	2	/	/	1	1	1	1	0.5	0	4.5	75.0%
PS20 Bauer-Marschallinger et al. (2023) CLIL for All? Pedagogical Practices in Austria	3	/	/	1	1	1	0.5	0.5	0	4.0	66.7%
PS21 Belobrovy (2023) CLIL Curriculum Implementation in Higher Education	1		/	1	1	0.5	1	0.5	0	4.0	66.7%
PS22 Wunberg et al. (2024) CLIL Effects on Academic Self-Concepts	3		/	1	1	1	1	1	0.5	5.5	91.7%