

Implementing CLIL Mathematics in Taiwan: Curriculum Use, Task Demand, and Instructional Challenges

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Abstract

This study examined the implementation of a first-grade Content and Language Integrated Learning (CLIL) mathematics curriculum through three interrelated dimensions: curriculum use, task cognitive demand, and linguistic and cognitive challenges. A mixed-method case study was conducted with four teachers from two Taiwanese elementary schools implementing the same CLIL mathematics curriculum. Data included classroom recordings, instructional materials, and semi-structured interviews. Mathematical tasks were analyzed for curriculum use and cognitive demand, while classroom and interview data were qualitatively analyzed to identify linguistic and cognitive challenges during instruction. Results showed that teachers relied predominantly on textbook-based tasks, with relatively limited adaptation and creation. Procedures with Connections constituted the most frequent task type, indicating that higher-cognitive-demand tasks primarily involved conceptual connections within structured procedures, whereas Doing Mathematics tasks requiring non-routine reasoning, strategy exploration, and justification were rare. Linguistic and cognitive challenges were closely intertwined, particularly in maintaining linguistic precision in mathematical meaning-making and sustaining cognitive demand through mathematical interaction in an additional language. Teachers' curriculum use and classroom enactment appeared to be influenced by instructional experience, linguistic confidence, and task demands. These findings suggest that CLIL mathematics implementation involves ongoing negotiation among curriculum resources, mathematical task demands, and linguistic support. By examining these dimensions together, the study provides a context-specific account of how Content, Cognition, and Communication interact during CLIL mathematics curriculum implementation, with implications for curriculum design and teacher development.

Keywords: CLIL mathematics; curriculum implementation; cognitive demand; linguistic scaffolding

1. Introduction

Content and Language Integrated Learning (CLIL) has increasingly been adopted to integrate subject learning with additional-language development. Rather than treating language as a separate instructional objective, CLIL positions language as a resource through which disciplinary knowledge is accessed, constructed, and communicated (Coyle et al., 2010). In Taiwan, recent bilingual education initiatives have encouraged schools to incorporate English into non-language subjects, including mathematics, creating a growing need to understand how content and additional-language learning can be integrated in classroom practice (Graham & Yeh, 2022; Huang & Tsou, 2023). Mathematics provides a particularly important context for examining CLIL because learning involves not only acquiring concepts and procedures but also interpreting relationships, explaining strategies, representing ideas, and communicating mathematical reasoning.

Implementing mathematics through an additional language consequently creates interconnected content, cognitive, and linguistic demands. Students must engage with mathematical concepts while developing the language needed to understand and communicate mathematical meanings (Cambridge ESOL, 2010). This is particularly important for young learners, whose additional-language resources may not yet support the discipline-specific language required for mathematical reasoning. Teachers therefore need to maintain appropriate mathematical challenge while making content and language accessible through representations, questioning, modelling, and linguistic scaffolding (Kersaint et al., 2013). The mathematical tasks teachers select and enact are particularly important because they shape the level of mathematical thinking students are expected to engage in (Stein et al., 1996). The challenge is therefore not

simply how much English should be used, but how teachers manage linguistic demands while preserving opportunities for mathematical thinking and reasoning (Ceallaigh et al., 2017).

These demands make curriculum implementation central to understanding CLIL mathematics instruction. Curriculum materials do not directly determine classroom practice; teachers interpret and use them through processes of selection, adaptation, and transformation according to instructional goals and classroom conditions (Remillard, 1999). Stein et al.'s (2007) distinction among the written, intended, and enacted curriculum provides a useful perspective for examining curriculum implementation. A written CLIL mathematics curriculum may incorporate particular mathematical tasks and language supports, but how these are realized in practice depends on how teachers interpret these resources and enact them through classroom interaction. In this transformation, both the cognitive demand of mathematical tasks and the linguistic demands of instruction may be reshaped.

Although previous CLIL research has established the importance of integrating content and language (Binterová et al., 2014; Dobson, 2020), less is known about how CLIL mathematics curricula are transformed from written materials into classroom practice, particularly in early elementary education. Research therefore needs to move beyond descriptions of CLIL principles to examine how teachers interpret and implement written curriculum materials, what levels of cognitive demand characterize the mathematical tasks they enact, and what linguistic and cognitive challenges arise during classroom implementation. By examining these dimensions together, this study extends existing CLIL mathematics research beyond a primary focus on content–language integration to consider how curriculum use, mathematical task demand, and additional-language demands interact during classroom enactment. This integrated perspective provides a task- and classroom-level account of how Content, Cognition, and Communication are negotiated as a written CLIL mathematics curriculum is implemented in practice.

Accordingly, this study investigated the implementation of a first-grade CLIL mathematics curriculum in two Taiwanese elementary schools. Integrating the CLIL dimensions of Content, Cognition, and Communication with the written–intended–enacted curriculum perspective, the study addressed three questions:

- 1) How do teachers interpret and implement the written curriculum in CLIL mathematics classrooms? (RQ1)
- 2) What levels of cognitive demand characterize the mathematical tasks enacted in CLIL mathematics classrooms? (RQ2)
- 3) What linguistic and cognitive challenges do teachers encounter when enacting CLIL mathematics instruction? (RQ3)

2. Literature Review

2.1 Content, Cognition, and Communication in CLIL Mathematics Classrooms

CLIL is a dual-focused approach in which an additional language is used to teach and learn both subject content and language. Coyle et al. (2010) conceptualized CLIL through the 4Cs Framework: Content, Communication, Cognition, and Culture. In mathematics classrooms, these dimensions require students not only to develop mathematical knowledge but also to use language to interpret problems, explain reasoning, and participate in mathematical discourse (Ouazizi, 2016). Although Culture is integral to the framework, CLIL mathematics research has tended to emphasize the interaction among content, cognition, and communication, particularly how language mediates mathematical understanding and reasoning (Favilli et al., 2013). Accordingly, this review focuses on these three dimensions. Within CLIL mathematics, content refers not simply to mathematical topics but also to the concepts, procedures, representations, and mathematical practices that students are expected to develop. The integration of content with cognition and communication therefore requires attention to both what mathematical knowledge is taught and how learners reason about and communicate that knowledge.

Among these three dimensions, the relationship between communication and cognition is particularly important because mathematical language differs from everyday communication (Prochazkova, 2013). Cummins (1984) distinguished between Basic Interpersonal Communicative Skills (BICS) and Cognitive Academic Language Proficiency (CALP). Whereas BICS concerns conversational language supported by contextual cues, CALP involves language required in cognitively demanding academic contexts. While CALP provides a broader academic-language framework, the mathematical register specifies the discipline-specific vocabulary, symbolic representations, and discourse practices required for mathematical communication. Students must therefore move beyond technical vocabulary to explain procedures, compare quantities, justify solutions, and communicate mathematical reasoning (Lee, 2006).

This distinction is particularly relevant in early mathematics CLIL classrooms, where learners may understand routine English instructions but lack the linguistic resources to explain mathematical relationships. CLIL instruction must therefore support discipline-specific language while ensuring that limited additional-language proficiency does not restrict mathematical thinking (Slavit & Ernest-Slavit, 2007).

The interaction between linguistic and cognitive demands can be conceptualized through the CLIL Matrix (Coyle et al., 2010), which positions learning tasks along these two dimensions (Figure 1). Its curved trajectory represents a scaffolded progression, rather than a fixed sequence, toward increasingly demanding integration of language and cognition. Learners may initially engage with cognitively meaningful mathematics through accessible language and contextual support, such as manipulatives, visual representations, gestures, mathematical symbols, and teacher modelling (Meyer, 2010). As their linguistic resources develop, they can undertake tasks requiring more sophisticated reasoning and academic language. The pedagogical goal is therefore to maintain cognitive challenge while providing sufficient linguistic scaffolding.

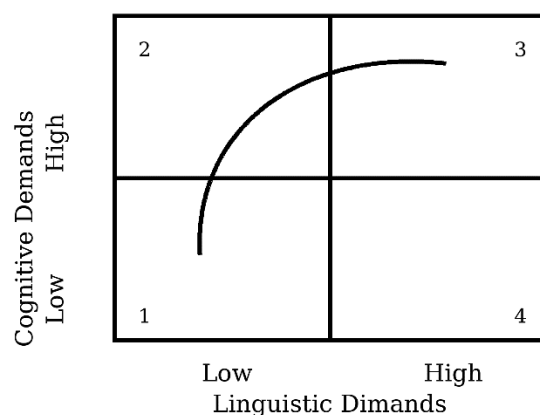


Figure 1. CLIL Matrix

Note. The CLIL matrix illustrates the relationship between cognitive and linguistic demands. From *Content and Language Integrated Learning* (p. 43), by D. Coyle, P. Hood, and D. Marsh, 2010, Cambridge University Press. Copyright 2010 by Cambridge University Press.

Integrating mathematical content with these linguistic and cognitive demands also creates professional challenges for CLIL teachers, who must work across disciplinary and linguistic boundaries. Effective mathematics CLIL instruction requires mathematical content knowledge, pedagogical knowledge, academic language awareness, and CLIL pedagogy (Frigols et al., 2007). Teachers must coordinate mathematical tasks, representations, questioning, and linguistic support while balancing accessibility with cognitive challenge. Individual differences in knowledge, experience, and linguistic confidence may therefore shape instructional decisions.

CLIL principles, however, do not directly determine classroom practice. Their realization depends on how teachers interpret curriculum materials, select and adapt mathematical tasks, provide linguistic support, and make instructional decisions (Grouws et al., 2013). Understanding CLIL mathematics therefore requires examining how content, cognition, and communication are transformed from curriculum materials into planned and enacted instruction, leading to the perspective of curriculum implementation.

2.2 Curriculum Implementation in Mathematics Classrooms

Curriculum implementation is an interpretive and transformative process rather than a direct translation of curriculum materials into classroom practice. Teachers interpret, adapt, and transform curriculum resources according to their professional knowledge, instructional goals, and classroom contexts (Remillard & Bryans, 2004). Classroom instruction therefore emerges through interactions among curriculum materials, teachers, and contextual conditions (Nicol & Crespo, 2006).

Stein et al. (2007) conceptualize curriculum implementation as transformation across three interconnected stages: the written, intended, and enacted curriculum (Figure 2). The written curriculum consists of standards, textbooks, and instructional materials; the intended curriculum represents teachers' interpretations and instructional planning; and the enacted curriculum refers to how planned tasks are realized through classroom interaction. This framework highlights teachers' active role in transforming curriculum from materials into practice.

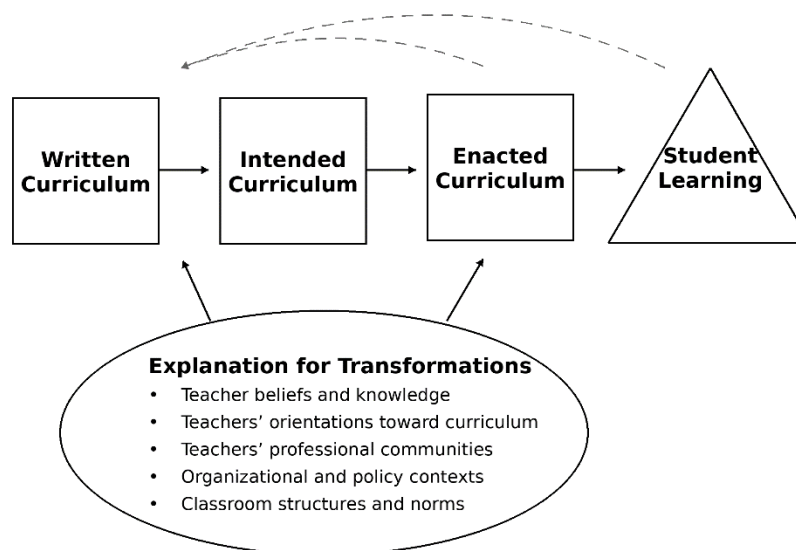


Figure 2. Curriculum Implementation Framework

Note. From “How Curriculum Influences Student Learning” (p. 322), by M. K. Stein, J. T. Remillard, and M. S. Smith, 2007, in F. K. Lester, Jr. (Ed.), *Second Handbook of Research on Mathematics Teaching and Learning*. Information Age Publishing. Copyright 2007 by Information Age Publishing.

At the written curriculum stage, curriculum materials provide formal guidance regarding mathematical content, task design, and instructional sequencing, but they do not determine how instruction will be enacted. Teachers interpret these resources in relation to their professional knowledge, instructional purposes, and classroom contexts (Lloyd, 2008). Brown and Edelson (2003) conceptualize curriculum use along a continuum from faithful implementation to adaptation and improvisation, while Sherin and Drake (2009) describe teachers' interactions with curriculum materials in terms of processes such as omission, replacement, and creation. These perspectives emphasize that teachers actively shape the curriculum rather than simply reproduce it.

The intended curriculum represents the stage at which teachers transform curriculum goals into instructional plans, including the selection, adaptation, and sequencing of mathematical tasks. Task selection is particularly important because it shapes students' opportunities to engage with mathematical ideas (Henningsen & Stein, 1997). Stein et al. (2007) classify mathematical tasks into four levels of cognitive demand: memorization, procedures without connections, procedures with connections, and doing mathematics. The first two emphasize recall and routine procedures, whereas the latter two require greater conceptual reasoning, representation, explanation, or justification. Examining mathematical tasks therefore provides a means of understanding the cognitive demand represented in curriculum materials and how that demand is subsequently realized in classroom instruction.

The enacted curriculum refers to how planned tasks are realized through classroom interaction. Importantly, the cognitive demand represented in a mathematical task is not necessarily preserved during classroom enactment. During instruction, teachers continually interpret student responses and make moment-to-moment decisions that may maintain, modify, or reduce the cognitive demand of a task (Stein et al., 1996). In CLIL classrooms, these decisions also involve managing linguistic demands, for example by adjusting explanations, providing visual or verbal scaffolds, reformulating questions, or modifying the language required for student participation (Dalton-Puffer, 2011). The enacted curriculum therefore provides a critical site for examining how mathematical content, cognitive demand, and linguistic support are negotiated in actual classroom practice.

Collectively, the CLIL dimensions of content, cognition, and communication and the written–intended–enacted perspective provide complementary lenses for examining CLIL mathematics implementation. The former identifies the mathematical, cognitive, and linguistic dimensions of instruction, whereas the latter explains how these dimensions are interpreted and transformed from curriculum materials into classroom practice. Their integration therefore offers a conceptual basis for examining how CLIL mathematics curricula are interpreted, planned, and enacted.

3. Research Framework

Drawing on the literature, this study brings together the Content, Cognition, and Communication dimensions of CLIL with the written–intended–enacted curriculum perspective to examine CLIL mathematics curriculum implementation (Figure 3). The written–intended–enacted distinction provides a broader conceptual perspective for understanding curriculum implementation, while the empirical analysis focuses on how the written curriculum is interpreted and enacted in classroom practice.

The CLIL Matrix served as a conceptual heuristic for interpreting the relationship between linguistic accessibility and cognitive demand rather than as a separate coding scheme. The empirical analysis was organized around three interrelated dimensions: teachers' interpretation and implementation of the written curriculum (RQ1), the cognitive demand of mathematical tasks as enacted in classroom instruction (RQ2), and the linguistic and cognitive challenges teachers encountered during CLIL mathematics instruction (RQ3). Together, these dimensions provide insight into how CLIL mathematics curricula are interpreted and transformed into classroom practice and how Content, Cognition, and Communication interact during implementation.

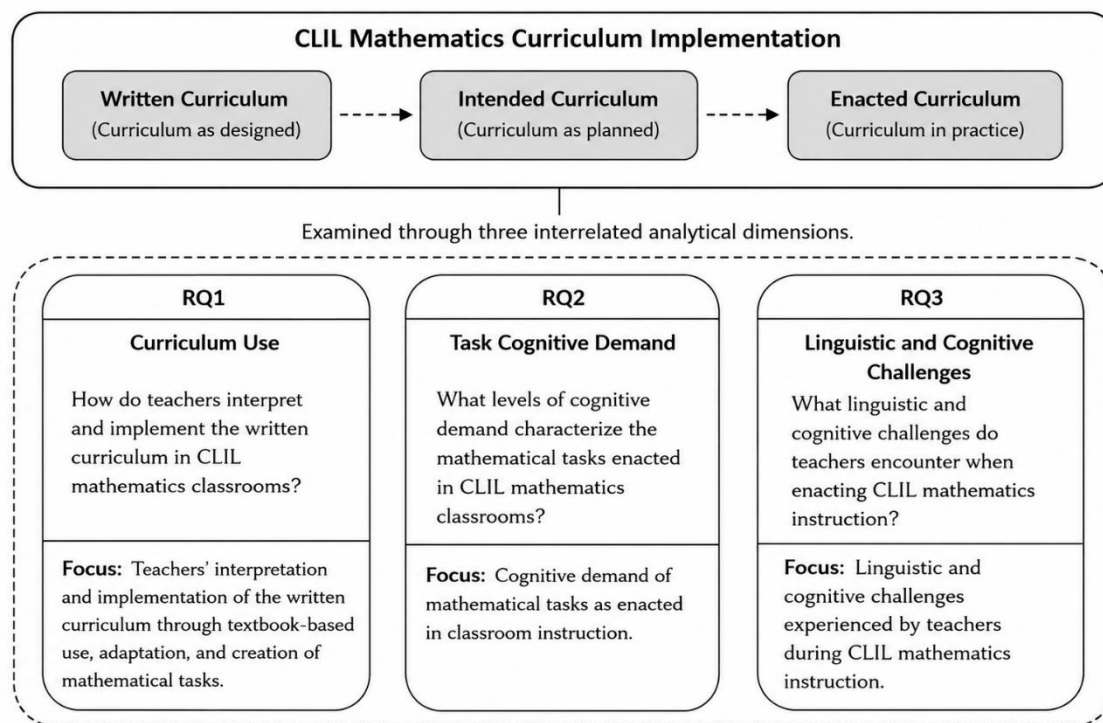


Figure 3. Research Framework

4. Methodology

4.1 Research Design

This study employed a mixed-method case study design to investigate the implementation of a first-grade CLIL mathematics curriculum in two elementary schools in Taiwan. A case study approach was appropriate because curriculum implementation is a situated and interpretive process shaped by teachers' instructional decisions and classroom contexts (Priya, 2021).

The case was bounded by the implementation of the same first-grade CLIL mathematics curriculum in the two schools. Guided by the research framework described above, quantitative task-level analysis was combined with qualitative analysis of classroom observations and teacher accounts to examine teachers' curriculum use, the cognitive demand of enacted mathematical tasks, and the linguistic and cognitive challenges encountered during classroom instruction.

4.2 School Sites and Participants

Since 2020, the researcher has collaborated with local elementary schools through professional development workshops on CLIL mathematics instruction. The workshops addressed mathematical task design, cognitive demand,

and linguistic scaffolding informed by the CLIL Matrix. Because the researcher had previously facilitated these workshops, the participating teachers had an established professional relationship with the researcher before data collection. The potential influence of this dual role is addressed in the limitations of the study. Two schools were purposefully selected from the participating schools. School A, in central Taiwan, and School B, in northern Taiwan, were early adopters of bilingual education initiatives with administrative support for CLIL implementation.

Four teachers were purposefully selected from approximately 20 workshop participants based on their relevance to the bounded case: they were teaching first-grade mathematics during the study semester, were implementing the same CLIL mathematics curriculum, and agreed to participate in classroom recording and interviews. The selection also enabled the study to examine implementation across two school contexts while holding grade level and curriculum materials constant. TA and TB were from School A, while TC and TD were from School B. The teachers had varying levels of teaching experience: TA had 26 years of experience, TB 6 years, TC 5 years, and TD 14 years. English proficiency also varied; TB and TC had demonstrated proficiency at CEFR B2 or above, whereas TA and TD had not reported equivalent English certification. None of the four teachers had prior experience teaching mathematics through CLIL before participating in the study.

4.3 Data Collection

The four teachers implemented first-grade CLIL mathematics instruction using the *CLIL Mathematics Course Book–1B* (Lu & Yuan, 2023) over an 18-week semester. The textbook contains 10 units, of which Units 1–8 were included in the participating schools' instructional schedule. Data collection focused on six units, Units 1, 2, 4, 5, 7, and 8, as Units 3 and 6 could not be recorded due to school-wide events and examination schedules (Table 1). Data sources included classroom recordings, instructional materials, and semi-structured interviews.

Table 1. Instructional Units Included in Data Collection

Unit	TA	TB	TC	TD
Unit 1: Addition	✓	✓	✓	✓
Unit 2: Subtraction	✓	✓	✓	✓
Unit 3: Length	—	—	—	—
Unit 4: Shapes	✓	✓	✓	✓
Unit 5: Classification	✓	✓	✓	✓
Unit 6: Numbers 31-50	—	—	—	—
Unit 7: Numbers 51-100	✓	✓	✓	✓
Unit 8: Money	✓	✓	✓	✓

Note. ✓ indicates units included in data collection; — indicates units not recorded.

4.3.1 Classroom Recordings

Two 40-minute lessons from each of the six units were video-recorded for each teacher, resulting in approximately 480 minutes per teacher and 1,920 minutes (32 hours) across the four teachers. The recordings captured mathematical tasks, instructional explanations, language use, and teacher–student interactions. All recorded lessons were transcribed verbatim.

4.3.2 Instructional Materials

The *CLIL Mathematics Course Book–1B* (Lu & Yuan, 2023), lesson plans, worksheets, and teacher-developed or adapted materials associated with the recorded units were collected. The textbook, worksheets, and teacher-developed or adapted materials were used to identify and compare mathematical tasks with their classroom enactment. Lesson plans were used as contextual references to support interpretation of teachers' instructional decisions and interview accounts rather than as a separately coded representation of the intended curriculum.

4.3.3 Semi-Structured Interviews

Each teacher participated in an individual 60–90-minute semi-structured interview via Google Meet at the end of the semester. Questions addressed teachers' curriculum use, instructional decisions concerning mathematical tasks, and linguistic and cognitive challenges encountered during instruction. Example questions included: “What factors influenced how you used or adapted the curriculum materials and mathematical tasks?” and “What linguistic or

cognitive challenges did you encounter when implementing the lessons?" All interviews were audio-recorded, conducted in Mandarin, transcribed verbatim, and subsequently translated into English for analysis.

4.4 Data Analysis

Data analysis was organized around the three research questions and their corresponding analytical dimensions: Curriculum Use (RQ1), Task Cognitive Demand (RQ2), and Linguistic and Cognitive Challenges (RQ3). The mathematical task served as the unit of analysis for RQ1 and RQ2, with coding informed by curriculum-use and mathematical-task frameworks. Fisher-Freeman–Halton exact tests (Freeman & Halton, 1951) were used to examine the distributions of curriculum-use and cognitive-demand categories across the four teachers. Because tasks were nested within a small number of teacher cases, the statistical results were treated as supplementary to the descriptive, case-based analysis rather than as evidence of generalizable teacher-level differences. RQ3 involved qualitative analysis of classroom and interview data using open coding procedures (Strauss & Corbin, 1990). The CLIL Matrix was used as an interpretive heuristic for considering the relationship between linguistic and cognitive demands across these analyses; it was not used as an independent coding framework. Evidence across the three analyses was subsequently integrated to develop an overall account of CLIL mathematics curriculum implementation.

4.4.1 Coding Unit and Task Boundaries

The mathematical task served as the primary unit for curriculum-use and cognitive-demand coding. Following Stein et al. (2007), a task was defined as a coherent instructional segment organized around a particular mathematical goal, problem, or set of closely related problems that provided students with an opportunity to engage with a mathematical idea.

Task boundaries were determined primarily by a change in mathematical or pedagogical objective, rather than by duration or activity format. A new task was identified when there was a substantive shift in (a) the mathematical concept or learning objective, (b) the pedagogical purpose, such as moving from procedural practice to strategy comparison, or (c) materials or representations that introduced a different mathematical activity. Conversely, explanation, demonstration, questioning, use of manipulatives, and guided practice were treated as part of the same task when they supported the same mathematical objective.

4.4.2 Analytical Procedures

For RQ1, curriculum use was coded by comparing textbook tasks with instructional materials and classroom enactment. Drawing on Brown and Edelson's (2003) framework of curriculum use and Sherin and Drake's (2009) conceptualization of teachers' interactions with curriculum materials, three coding categories were developed: textbook-based (CUT), tasks implemented from the textbook without substantive modification; adapted (CUA), textbook tasks modified in content, representation, procedure, or instructional organization; and teacher-created (CUC), tasks introduced by the teachers but not included in the textbook. Interview data were used to clarify teachers' curriculum-use decisions.

For RQ2, enacted mathematical tasks were classified according to four levels of cognitive demand adapted from Stein et al. (2007): Memorization (MTM), requiring recall of facts or definitions; Procedures without Connections (MTP), involving routine procedures without conceptual connections; Procedures with Connections (MTC), connecting procedures with mathematical concepts or representations; and Doing Mathematics (MTD), requiring non-routine reasoning, explanation, justification, exploration, or strategy comparison. The distinction between MTC and MTD was based primarily on the nature of the mathematical reasoning required. MTC tasks involved procedures explicitly connected to mathematical concepts or representations, with a relatively structured or predictable solution pathway. In contrast, MTD tasks required students to engage in non-routine mathematical thinking, such as exploring alternative strategies, developing their own solution approaches, or justifying mathematical relationships without a prescribed solution procedure. Coding decisions were based on the cognitive demands of tasks as enacted in classroom instruction rather than solely on their intended demands in the textbook.

For RQ3, classroom transcripts and interviews were analyzed through open coding (Strauss & Corbin, 1990) to identify linguistic and cognitive challenges encountered during CLIL mathematics instruction. Related codes were compared and grouped into broader categories and subthemes. Interview accounts were used to clarify instructional decisions and contextual factors contributing to the identified challenges.

Finally, findings from classroom recordings, instructional materials, and interviews were compared across the three analyses to identify converging and complementary evidence and develop an integrated understanding of CLIL mathematics curriculum implementation.

4.5 Reliability and Validity

To enhance coding reliability, the first author and a trained research assistant reviewed the coding manual and jointly coded one classroom session to calibrate task-boundary decisions and the application of the curriculum-use and cognitive-demand coding schemes. They then independently coded approximately one instructional unit. Discrepancies were discussed, coding rules refined, and the subset independently recoded. Cohen's kappa (Cohen, 1960) was then calculated separately for curriculum-use and cognitive-demand coding. The resulting κ values were .86 for curriculum-use coding and .83 for cognitive-demand coding, indicating strong interrater agreement. Remaining disagreements were subsequently resolved, and the finalized criteria were applied to the remaining data. Trustworthiness of the qualitative challenge analysis was strengthened through comparison of classroom and interview evidence, while overall validity was enhanced through methodological triangulation across classroom recordings, instructional materials, and interviews.

5. Results and Discussion

The six recorded instructional units served as the basis for task-level analysis. Using the task-boundary criteria described in the Data Analysis section, 173 mathematical tasks were identified: 39 for TA, 41 for TB, 48 for TC, and 45 for TD (Table 2). For the task-level analyses addressing RQ1 and RQ2, Fisher-Freeman-Halton exact tests were conducted to examine whether the distributions of curriculum-use categories and cognitive-demand categories differed across the four teachers. Neither test was statistically significant ($p > .05$); therefore, teacher-level percentage differences are interpreted as descriptive, case-based patterns rather than statistically established differences.

Table 2. Distribution of Mathematics Tasks Across Units and Teachers

Unit	TA	TB	TC	TD	Total
Unit 1: Addition	8	8	8	8	32
Unit 2: Subtraction	7	7	9	8	31
Unit 4: Shapes	7	8	8	9	32
Unit 5: Classification	6	6	8	8	28
Unit 7: Numbers 51-100	5	6	7	6	24
Unit 8: Money	6	6	8	6	26
Total Number of Mathematical Tasks	39	41	48	45	173

5.1 Teachers' Interpretation and Implementation of the Written CLIL Mathematics Curriculum

RQ1 examined teachers' interpretation and implementation of the written CLIL mathematics curriculum, corresponding to the Curriculum Use dimension of the research framework. Tasks were classified as textbook-based (CUT), adapted (CUA), or teacher-created (CUC) (Table 3).

Table 3. Distribution of Curriculum Use Across Teachers

Types of Curriculum Use	TA	TB	TC	TD	Total
CUT	27 (69%)	35 (85%)	48 (100%)	41 (91%)	151 (87%)
CUA	5 (13%)	4 (10%)	0 (0%)	3 (7%)	12 (7%)
CUC	7 (18%)	2 (5%)	0 (0%)	1 (2%)	10 (6%)
Total	39	41	48	45	173

Overall, 87% of tasks were implemented directly from the textbook, indicating that the written curriculum was the dominant instructional resource. Classroom and interview evidence, however, showed that close adherence to the textbook reflected different instructional considerations across teachers.

5.1.1 Textbook-Based Curriculum Use as Support for Mathematical and Linguistic Uncertainty

A key finding was that close adherence to the textbook could serve as a form of instructional support, although the source of uncertainty differed across teachers. This was particularly evident in TC and TD, whose instruction was predominantly textbook-based. During a data-recording lesson, TC followed a textbook activity requiring students to tally shapes (Figure 4):

TC: Remember to tick off each button as you count.

TC: One triangle, one tally mark...

Ss: 可以直接數嗎? 為什麼要記錄? (*Can we just count directly? Why do we need to record it?*)



Figure 4. A Mathematical Task on a Classification Activity

Note. From *CLIL Mathematics: Course Book 1B* (p. 59), by Y.-H. Lu and Y. Yuan, 2023, MindKee Co. Ltd.
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Although students could perform the procedure, their question revealed uncertainty about its mathematical purpose: why use tally marks when the objects could simply be counted? TC later explained:

“This was my first time teaching this unit in English. I felt more secure following the textbook so that I wouldn’t misinterpret the content.” (TC interview)

For TC, the textbook therefore functioned as an instructional script, providing structure for teaching unfamiliar mathematical content but offering limited support when students raised an unanticipated conceptual question. Given TC’s demonstrated English proficiency at CEFR B2 or above, her reliance on the textbook appeared to reflect uncertainty about teaching unfamiliar mathematical content through English rather than limited general English proficiency.

TD also relied heavily on textbook-based tasks, but for a different reason. During a shapes lesson, she followed the textbook activity requiring students to reproduce cube configurations (Figure 5):

TD: Turn to page 47.

TD: Now, use the cubes on your desk to make the same shape as the one on page 47.



Figure 5. Shapes

Note. From *CLIL Mathematics: Course Book 1B* (p. 47), by Y.-H. Lu and Y. Yuan, 2023, MindKee Co. Ltd.
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The activity could be enacted through short, predictable classroom language and required little extended mathematical explanation. TD explained:

“I worry a lot. I am afraid to adapt or create tasks beyond the textbook because my English is not strong enough. Therefore, I prefer to follow the textbook.” (TD interview)

The two cases show that similar patterns of textbook-based curriculum use may reflect different forms of instructional uncertainty. TC relied on the textbook partly to manage unfamiliar mathematical content, whereas TD used it to reduce the linguistic uncertainty of English-medium instruction. From a CLIL perspective, the written curriculum theref

ore provided support for negotiating different aspects of Content and Communication. At the same time, close adherence could constrain teachers' opportunities to modify tasks when greater conceptual explanation or linguistic support was needed.

5.1.2 Curriculum Adaptation as Coordination of Content, Cognition, and Communication

Although curriculum adaptation and creation were relatively uncommon overall, TA's case illustrates how transforming a textbook task could strengthen its mathematical purpose. When teaching data recording, TA replaced the textbook activity with a video of differently colored cars moving across the screen:

TA: How many red cars have passed?

Ss: 很難數... (*It is difficult to count.*)

TA: Right, it is very difficult to count, so we need to use tally marks.

TA: Now... one red car... draw one tally mark under the red car...

By making direct counting difficult, the adapted task created a need for recording. Tally marks consequently became a mathematical solution to a problem rather than a procedure students were simply expected to reproduce. Compared with the textbook-based activity observed in TC's lesson, the adaptation changed the cognitive purpose of the activity by connecting the procedure more explicitly to its underlying mathematical meaning.

TA associated this flexibility with her previous instructional experience but also emphasized the additional demands imposed by CLIL:

"I used to modify materials or design mathematical tasks to fit my instructional objectives. However, preparing CLIL mathematics lessons requires much more work. I have to think about the content and also consider the language. I have to balance both to support students' understanding." (TA interview)

TA's example illustrates that curriculum adaptation in CLIL involves more than modifying activities. Teachers must consider whether a task makes the mathematical purpose accessible, sustains appropriate cognitive engagement, and can be enacted through language that students can understand. In terms of the CLIL Matrix, effective adaptation therefore involves coordinating cognitive demand with linguistic accessibility, rather than simply simplifying either mathematics or language.

Across the cases, teachers' interpretation and implementation of the written curriculum were shaped by instructional experience, linguistic confidence, and task demands. The textbook provided support when teachers faced mathematical or linguistic uncertainty, whereas adaptation could strengthen connections between procedures and conceptual purposes. These patterns illustrate how Curriculum Use connects the written curriculum with classroom implementation, requiring teachers to negotiate Content, Cognition, and Communication when deciding whether to follow, adapt, or extend curriculum materials.

5.2 Cognitive Demand of Enacted Mathematical Tasks

To address RQ2, the 173 enacted mathematical tasks were classified as MTM, MTP, MTC, or MTD. The former two represented lower-cognitive-demand tasks, whereas the latter two represented higher-cognitive-demand tasks (Table 4).

Table 4. Examples of Mathematical Task Types

Cognitive Demand	Task type	Example
Lower	MTM	Reciting addition facts within 20
	MTP	Solving $8 + 5$, $7 + 6$, and $9 + 4$ using counting-on without explanation
Higher	MTC	Using ten-frames to demonstrate how $8 + 5$ forms a new ten
	MTD	Comparing counting-on and making-ten strategies and explaining why

As shown in Table 5, MTC was the most frequent task type (55%), followed by MTM (23%), MTP (16%), and MTD (6%). Overall, higher-cognitive-demand tasks accounted for 106 tasks (61%).

Table 5. Distribution of Mathematical Task Types Across Teachers

Cognitive Demand	Task type	TA	TB	TC	TD	Total
Lower	MTM	4 (10%)	8 (20%)	16 (33%)	11 (24%)	39 (23%)
	MTP	3 (8%)	7 (17%)	12 (25%)	6 (13%)	28 (16%)
	Subtotal	7 (18%)	15 (37%)	28 (58%)	17 (38%)	67 (39%)
Higher	MTC	29 (74%)	24 (59%)	17 (35%)	25 (56%)	95 (55%)
	MTD	3 (8%)	2 (5%)	3 (6%)	3 (7%)	11 (6%)
	Subtotal	32 (82%)	26 (63%)	20 (42%)	28 (62%)	106 (61%)
Total		39 (100%)	41 (100%)	48 (100%)	45 (100%)	173 (100%)

Note. Percentages are calculated within each teacher's total; total percentages are based on 173 tasks.

5.2.1 Higher-Cognitive-Demand Tasks

The predominance of MTC tasks indicates that teachers frequently connected mathematical procedures with concrete or visual representations. Figure 6 illustrates this pattern in TA's subtraction instruction, where counting backward, a number bond, and a ten-frame were used for different subtraction problems.

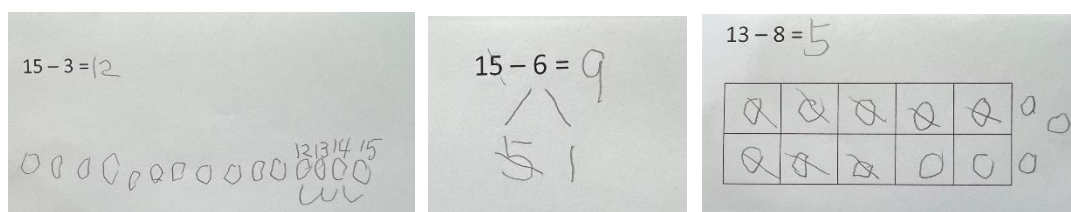


Figure 6. Three Strategies for Subtraction

Although all three were classified as MTC, their linguistic demands differed. Counting backward required relatively predictable language, whereas the number-bond strategy required relational language to explain part-whole relationships. The ten-frame visually represented quantitative relationships, reducing reliance on verbal explanation. Such representations can help maintain mathematical challenge while making linguistic demands more manageable. TA explained:

“In CLIL classrooms, I was concerned that students might not understand the English instruction, so I needed to use different representations and methods to help them understand the mathematical concepts.” (TA interview)

Thus, representations functioned as both mathematical and linguistic scaffolds, enabling teachers to maintain conceptual connections while making higher-cognitive-demand tasks more accessible through an additional language. Although both MTC and MTD were classified as higher-cognitive-demand tasks, MTC primarily involved conceptual connections within relatively structured procedures, whereas MTD required greater independence in exploring strategies and justifying mathematical relationships. Only 11 tasks (6%) were classified as MTD, suggesting that opportunities for higher-level mathematical thinking were concentrated primarily in connecting procedures with mathematical concepts rather than in extended, non-routine mathematical inquiry. Such inquiry may also place greater linguistic demands on young learners, particularly when they are expected to communicate their mathematical reasoning in English. TB noted:

“I often asked students to compare or explain different strategies for solving a task in my Chinese-taught lessons; however, because of their limited English proficiency, I felt that they might not be able to clearly explain the reasoning behind the strategies.” (TB interview)

The predominance of MTC may also be associated with the instructional emphasis on manipulatives and visual representations in first-grade mathematics, which can support the transition from concrete activity toward more abstract reasoning. However, TB's account suggests that students' limited English resources may have constrained opportunities for extended mathematical explanation and strategy comparison. Thus, within these four cases, the rarity of MTD tasks appeared to reflect the challenges of sustaining non-routine mathematical reasoning and extended mathematical communication through an additional language.

5.2.2 Lower-Cognitive-Demand Tasks

Lower-cognitive-demand tasks accounted for 67 tasks (39%), including MTM (23%) and MTP (16%). Descriptively, their use ranged from 18% of TA's tasks to 58% of TC's tasks. In TC's classroom, some lower-cognitive-demand activities emphasized English sentence patterns:

TC: 18 minus 7 equals...? What is the answer?
 Ss: 11.
 TC: Yes. Please repeat after me. 18 minus 7 equals 11.
 Ss: 18 minus 7 equals 11.
 TC: Good. One more time.
 Ss: 18 minus 7 equals 11.

Here, English functioned primarily as an object of practice rather than a resource for mathematical communication. Although repetition supported familiarity with mathematical sentence patterns, it provided limited opportunities for mathematical explanation or reasoning. The activity therefore combined low cognitive demand with predictable linguistic production, illustrating how linguistic and cognitive demands operated together during classroom enactment. This pattern suggests that the cognitive demand of an enacted task may be shaped not only by its mathematical content but also by how content and language are coordinated during classroom instruction.

5.3 Linguistic and Cognitive Challenges in Enacting CLIL Mathematics Instruction

To address RQ3, this study examined the linguistic and cognitive challenges teachers encountered when enacting CLIL mathematics instruction. The findings revealed two interconnected challenges: maintaining linguistic precision in mathematical meaning-making and sustaining cognitive demand through mathematical interaction in an additional language. The first concerned the accurate and conceptually appropriate use of mathematical language, while the second involved supporting meaningful mathematical interaction and reasoning when additional-language demands increased.

5.3.1 Maintaining Linguistic Precision in Mathematical Meaning-Making

Classroom observations revealed that pronunciation, terminology, and grammatical choices occasionally interfered with the communication of mathematical meaning. During a subtraction task, for example, TA mispronounced *sixteen*, placing stress on the first syllable. The student consequently interpreted the number as 60:

TA: Tom, what will you get if you subtract 3 from 16 [SIX-teen]?
 TA: Please write the number sentence on the whiteboard.
 (Tom wrote "60 - 3 =" on the whiteboard.)
 TA: No... I mean 16 [SIX-teen] minus 3
 S: ...
 TA: 十六減三 (16 minus 3.)

Although the subtraction itself was cognitively straightforward, inaccurate pronunciation increased the linguistic difficulty and disrupted access to the mathematical task. The problem therefore originated in language form rather than mathematical reasoning. A related challenge involved terminological precision. During number comparison, TB alternated among *more*, *greater*, and *larger*:

TB: Which are *greater*, the white roses or the red roses?
 TB: Let's compare the tens first. 8 is *larger* than 6, so 83 is *more* than 65.

Although the numerical reasoning was correct, the interchangeable use of these terms blurred distinctions among quantity, numerical magnitude, and physical size. In another case, cross-linguistic transfer also affected TD's mathematical language when she used *minus* as a verb:

TD: 15 minus 6 equals...? What can we do?
 TD: Look at the number 6 here... 5 and 1 make 6, right?
 TD: So, we can *minus* 5 from 15. 15 minus 5 equals 10.

In conventional English mathematical usage, *subtract* functions as the verb, whereas *minus* typically expresses the operation or relation. TD's usage appears to reflect Mandarin transfer, as 減 can function verbally and correspond to both *subtract* and *minus*. Together, these episodes demonstrate that linguistic accuracy in CLIL mathematics is closely connected to mathematical meaning: even when teachers' mathematical reasoning is correct, imprecise pronunciation, terminology, or grammatical choices can make that reasoning less accessible to students. TD described the difficulty of simultaneously managing these demands:

“I rarely speak English in my daily life. Even though I prepared and practiced some classroom language before the lesson, I could not always notice my own errors. It was very difficult to think about how to teach the mathematics and how to speak English accurately at the same time.” (TD interview)

Importantly, such challenges were not limited to teachers without reported evidence of higher general English proficiency. TC, who had demonstrated English proficiency at CEFR B2 or above, also encountered difficulty with discipline-specific mathematical vocabulary. During a subtraction lesson using number bonds, she used *divide* to describe decomposing a number:

TC: You may *divide* 6 into 1 and 5 first.

TC: Now, you can subtract 5 from 15 and... subtract 1 from 10.

TC: So... the answer is 9.

She later explained:

“We often divide students into groups, so I thought the word could also be used for separating a number into two parts.” (TC interview)

This case distinguishes general English proficiency from competence in the mathematical register. Higher general English proficiency may facilitate classroom communication but does not necessarily provide the specialized vocabulary and discourse knowledge required to express mathematical relationships precisely. The linguistic challenge in CLIL mathematics therefore involved not simply using English, but using discipline-appropriate language to construct mathematical meaning.

5.3.2 Sustaining Cognitive Demand through Mathematical Interaction in an Additional Language

A further challenge concerned sustaining cognitively meaningful mathematical interaction through English. When teachers perceived students' English resources as insufficient for extended responses, classroom discourse tended to rely on controlled and predictable forms of interaction. During a review of numbers from 51 to 100, for example, TC used oral repetition to practice skip counting:

TC: Let's review skip counting by 2.

Ss: 2, 4, 6, 8... 50.

TC: Let's review skip counting by 5.

Ss: 5, 10, 15, 20...50.

TC: Let's review skip counting by 10.

Ss: 10, 20, 30, 40, 50.

The activity enabled students to participate successfully through predictable language, but communication primarily involved recall rather than explanation or negotiation of mathematical meaning. TC explained:

“These first-grade students had no background in English, and I felt they lacked the proficiency to clearly express their answers. When I tried asking questions, students often remained silent. It is very challenging to use questioning to convey mathematical concepts in English.” (TC interview)

This finding is noteworthy because TC herself had demonstrated English proficiency at CEFR B2 or above. Higher teacher proficiency therefore did not remove the communicative challenge when students lacked the linguistic resources needed to participate in mathematical discourse. Questions requiring extended responses increased both linguistic and cognitive demands because students needed to understand the questions, formulate responses, and communicate mathematical reasoning in English. Teachers therefore sometimes reduced linguistic unpredictability through repetition and short-response interaction to maintain participation and classroom flow. Although this facilitated access, it could also limit opportunities to use language as a tool for mathematical reasoning.

A similar tension emerged when mathematical reasoning required more complex explanation or discussion of multiple strategies. Teachers sometimes responded by relying on direct explanation and a single solution method. When teaching the making-ten strategy for $8 + 5$, TD modeled one decomposition:

TD: What is the answer for 8 plus 5?

TD: Look here, we can first split 8 into 3 and 5.

TD: 5 and 5 make 10.

TD: Then, 10 plus 3 equals 13.

The explanation provided a clear procedure but did not invite students to propose alternative strategies or justify why the decomposition worked. TD reflected:

“I should have created opportunities for students to explore alternative strategies. However, I worried that presenting multiple solution methods might confuse them, especially because their English proficiency is limited.” (TD interview)

A related pattern appeared in conceptual explanation. During a comparison of 52 and 54, TB explained:

TB: Look, there are 52 roses and 54 sunflowers.

TB: Which are more? 52 roses or 54 sunflowers?

TB: Look here, the tens in 52 and 54 are the same. So, we need to compare the ones.

TB: 4 is greater than 2 so 54 is greater than 52.

Although mathematically correct, the explanation emphasized a comparison rule rather than explicitly developing the place-value relationship that both numbers contain five tens and differ only in their remaining units. A similar pattern occurred when TA presented a comparison problem involving 15 red scissors and 6 black scissors:

TA: How many more red scissors than black scissors are there?

TA: We need to subtract a smaller number from a greater number.

TA: 15 is greater than 6... so we need to subtract 6 from 15.

TA: 15 minus 6 equals...?

The procedure was explicit, but the conceptual meaning of *how many more* was not developed through visual comparison or one-to-one correspondence. Procedural explanation appeared linguistically easier to manage than conceptual elaboration, which required more extended and precise mathematical discourse. TA explicitly recognized this constraint:

“In a Chinese-taught mathematics class, I might delve into the *why* behind the solution. However, my limited English proficiency made it difficult for me to fully articulate the reasoning, leading me to focus on the *how*. It is easier to explain the solution directly when speaking English.” (TA interview)

Overall, these findings show that linguistic and cognitive challenges were interdependent rather than separate dimensions of classroom difficulty. Teachers generally maintained mathematical correctness, but additional-language demands influenced how deeply mathematical ideas could be discussed, compared, and explained. When questioning, conceptual elaboration, or strategy comparison required more complex language, interaction could shift toward predictable responses, direct modeling, and procedural guidance. The central challenge was therefore not simply how much English to use or how difficult the mathematics should be, but how to provide sufficient linguistic support to sustain cognitively meaningful mathematical interaction.

6. Pedagogical Implications

The findings have several implications for CLIL mathematics curriculum design and teacher development. First, the strong reliance on textbook-based tasks suggests that curriculum materials should provide more than prescribed activities and language expressions. They should make mathematical purposes explicit, offer alternative representations, and provide guidance for adapting tasks while preserving conceptual goals. Such support may help teachers use written curricula more responsively while managing mathematical and linguistic uncertainty.

Second, teacher preparation should develop discipline-specific mathematical language competence alongside general English proficiency. The challenges involving pronunciation, terminology, conceptual explanation, and classroom interaction indicate a need to integrate the mathematical register, questioning strategies, and linguistic scaffolding with mathematics pedagogy. Lesson rehearsal, classroom discourse analysis, and targeted feedback may help teachers communicate mathematical meaning more precisely and interactively.

Third, linguistic accessibility should support rather than reduce cognitive demand. Although higher-cognitive-demand tasks were common, most involved Procedures with Connections, while tasks requiring extended reasoning, comparison, and justification were rare. Visual representations, manipulatives, sentence frames, structured questioning, and strategic use of students' first language can help make mathematical ideas and interaction linguistically accessible while maintaining the conceptual goals of a task. Such support may enable students to participate more fully in mathematical reasoning while gradually developing the language needed to communicate their mathematical thinking.

7. Limitations

Several limitations should be considered when interpreting the findings. First, this study involved four teachers from two schools implementing the same first-grade CLIL mathematics curriculum. The findings therefore represent patterns within these specific cases and should not be generalized to CLIL mathematics classrooms more broadly.

Second, the researcher had previously facilitated the professional development workshops attended by the participating teachers. Although the study drew on multiple data sources to support triangulation, this prior relationship may have influenced teachers' classroom behavior or interview responses. Third, the study focused on curriculum implementation and classroom enactment rather than student learning outcomes. Although classroom recordings captured student participation and responses during mathematical tasks, these data were not systematically analyzed to evaluate individual students' mathematical understanding or language development. Consequently, the findings indicate the cognitive demands and interactional opportunities provided by the enacted tasks but do not establish their effects on students' mathematical learning or language development. Fourth, although lesson plans were collected, they were used primarily as contextual references rather than systematically analyzed as an independent representation of the intended curriculum. The study therefore provides a more detailed account of the relationship between written curriculum materials and classroom enactment than of teachers' pre-enactment curricular intentions. Finally, two instructional units could not be recorded because of school events and examination schedules; therefore, the analyzed lessons do not represent the complete semester of instruction.

8. Conclusion

This study examined the implementation of a first-grade CLIL mathematics curriculum through three interrelated dimensions: Curriculum Use, Task Cognitive Demand, and Linguistic and Cognitive Challenges, within a framework integrating Content, Cognition, and Communication with the written–intended–enacted curriculum perspective.

The findings showed that the written curriculum remained the dominant instructional resource, while teachers' decisions to follow, adapt, or extend materials were shaped by instructional experience, linguistic confidence, and task demands. In classroom enactment, Procedures with Connections constituted the largest task category, indicating that higher-cognitive-demand tasks primarily involved conceptual connections within structured procedures, whereas Doing Mathematics tasks requiring non-routine reasoning, strategy exploration, and justification were rare. Linguistic and cognitive challenges were closely intertwined: maintaining discipline-specific linguistic precision and sustaining cognitively meaningful mathematical interaction through an additional language remained challenging. Visual representations and linguistic scaffolding appeared to facilitate students' engagement with mathematical concepts while making instructional language more accessible.

Collectively, these findings suggest that CLIL mathematics implementation is not simply a linear translation of written curriculum into classroom practice, but an ongoing process of interpretation and instructional negotiation. Within the four cases examined in this study, teachers coordinate curriculum resources, mathematical task demands, and linguistic support as they enact instruction. Although the findings are context-specific and are not intended to be generalized to CLIL mathematics classrooms broadly, they provide a situated account of how curriculum use, mathematical task demand, and additional-language demands interact during classroom enactment, thereby illustrating how Content, Cognition, and Communication can be jointly examined in CLIL mathematics implementation.

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Authors contributions

Dr. Yen-Hui Lu were responsible for study design, drafting the manuscript and revising it.

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References

- Binterová, H., Petrášková, V., & Komínková, O. (2014). The CLIL method versus pupils' results in solving mathematical word problems. *The New Educational Review*, 38(4), 238-249. <https://doi.org/10.15804/tner.14.38.4.18>
- Brown, M., & Edelson, D. (2003). *Teaching as design: Can we better understand the ways in which teachers use materials so we can better design materials to support their changes in practice?* The Center for Learning Technologies in Urban Schools. Retrieved from http://inquirium.info/people/matt/teaching_as_design-Final.pdf
- Cambridge ESOL. (2010). *Teaching maths through English - a CLIL approach*. Cambridge ESOL. Retrieved from <https://www.cambridgeenglish.org/Images/168751-teaching-maths-through-english-a-clil-approach.pdf>
- Ceallaigh, T., Mhurchú, S., & Chríonín, D. (2017). Balancing content and language in CLIL: The experiences of teachers and learners. *Journal of Immersion and Content-Based Language Education*, 5(1), 58-86. <https://doi.org/10.1075/jicb.5.1.03oce>
- Cohen, J. (1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, 20(1), 37-46. <https://doi.org/10.1177/001316446002000104>
- Coyle, D., Hood, P., & Marsh, D. (2010). *Content and language integrated learning*. Cambridge University Press.
- Cummins, J. (1984). *Bilingualism and special education: Issues in assessment and pedagogy*. College Hill Press.
- Dalton-Puffer, C. (2011). Content-and-language integrated learning: From practice to principles? *Annual Review of Applied Linguistics*, 31, 182-204. <https://doi.org/10.1017/S0267190511000092>
- Dobson, A. (2020). Context is everything: Reflections on CLIL in the UK. *The Language Learning Journal*, 48(5), 508-518. <https://doi.org/10.1080/09571736.2020.1804104>
- Favilli, F., Maffei, L., & Peroni, R. (2013). Teaching and learning mathematics in a non-native language: Introduction of the CLIL methodology in Italy. *US-China Education Review A*, 3(6), 374-380.
- Freeman, G. H., & Halton, J. H. (1951). Note on an exact treatment of contingency, goodness of fit and other problems of significance. *Biometrika*, 38(1-2), 141-149. <https://doi.org/10.1093/biomet/38.1-2.141>
- Frigols, M. J., Marsh, D., & Naysmith, J. (2007). Competence-building for teachers of CLIL: Vocational education. In D. Marsh & D. Wolff (Eds.), *Diverse contexts - converging goals: CLIL in Europe* (pp. 33-46). Peter Lang.
- Graham, K., & Yeh, Y. (2022). Teachers' implementation of bilingual education in Taiwan: Challenges and arrangements. *Asia Pacific Education Review*, 24, 461-472. <https://doi.org/10.1007/s12564-022-09791-4>
- Grouws, D., Tarr, J., Chávez, Ó., Sears, R., Soria, V., & Taylan, R. (2013). Curriculum and implementation effects on high school students' mathematics learning from curricula representing subject-specific and integrated content organizations. *Journal for Research in Mathematics Education*, 44(2), 416-463. <https://doi.org/10.5951/jresmetheduc.44.2.0416>
- Henningsen, M., & Stein, M. (1997). Mathematical tasks and student cognition: Classroom-based factors that support and inhibit high-level mathematical thinking and reasoning. *Journal for Research in Mathematics Education*, 28(5), 524-549. <https://doi.org/10.2307/749690>
- Huang, Y. P., & Tsou, W. L. (2023). CLIL development in bilingual education in Taiwan: Past, present, and future.

- Curriculum & Instruction Quarterly*, 26(1), 1-26. [https://doi.org/10.6384/CIQ.202301_26\(1\).0001](https://doi.org/10.6384/CIQ.202301_26(1).0001)
- Kersaint, G., Thompson, D. R., & Petkova, M. (2013). *Teaching mathematics to English language learners*. Routledge. <https://doi.org/10.4324/9780203098561>
- Lee, C. (2006). *Language for learning mathematics: Assessment for learning in practice*. Open University Press.
- Lloyd, G. M. (2008). Curriculum use while learning to teach: One student teacher's appropriation of mathematics curriculum materials. *Journal for Research in Mathematics Education*, 39(1), 63-94. <https://www.jstor.org/stable/30034888>
- Lu, Y. H., & Yuan, Y. (2023). *CLIL mathematics: Course book 1B*. MindKee.
- Meyer, O. (2010). Towards quality-CLIL: Successful planning and teaching strategies. *Pulso*, 33, 11-29. <https://doi.org/10.58265/pulso.5002>
- Nicol, C., & Crespo, S. (2006). Learning to teach with mathematics textbooks: How preservice teachers interpret and use curriculum materials. *Educational Studies in Mathematics*, 62(3), 331-355. <https://doi.org/10.1007/s10649-006-5423-y>
- Ouazizi, K. (2016). The effects of CLIL education on the subject matter (mathematics) and the target language (English). *Latin American Journal of Content and Language Integrated Learning*, 9(1), 110-137. <https://doi.org/10.5294/lacil.2016.9.1.5>
- Priya, A. (2021). Case study methodology of qualitative research: Key attributes and navigating the conundrums in its application. *Sociological Bulletin*, 70(1), 94-110. <https://doi.org/10.1177/0038022920970318>
- Prochazkova, L. (2013). Mathematics for language, language for mathematics. *European Journal of Science and Mathematics Education*, 1(1), 23-28. <https://doi.org/10.30935/scimath/9383>
- Remillard, J. T. (1999). Curriculum materials in mathematics education reform: A framework for examining teachers' curriculum development. *Curriculum Inquiry*, 29(3), 315-342. <https://doi.org/10.1111/0362-6784.00130>
- Remillard, J. T., & Bryans, M. B. (2004). Teachers' orientations toward mathematics curriculum materials: Implications for teacher learning. *Journal for Research in Mathematics Education*, 35(5), 352-388. <https://doi.org/10.2307/30034820>
- Sherin, M. G., & Drake, C. (2009). Curriculum strategy framework: Investigating patterns in teachers' use of a reform-based elementary mathematics curriculum. *Journal of Curriculum Studies*, 41(4), 467-500. <https://doi.org/10.1080/00220270802696115>
- Slavit, D., & Ernest-Slavit, G. (2007). Teaching mathematics and English to English language learners simultaneously. *Middle School Journal*, 39(2), 4-11. <https://doi.org/10.1080/00940771.2007.11461618>
- Stein, M. K., Grover, B. W., & Henningsen, M. (1996). Building student capacity for mathematical thinking and reasoning: An analysis of mathematical tasks used in reform classrooms. *American Educational Research Journal*, 33(2), 455-488. <https://doi.org/10.3102/00028312033002455>
- Stein, M. K., Remillard, J. T., & Smith, M. S. (2007). How curriculum influences student learning. In F. K. Lester, Jr. (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 319-369). Information Age Publishing. <https://doi.org/10.1108/978-1-28141-200-320251012>
- Strauss, A. L., & Corbin, J. M. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. Sage.