mathematics

Systematic Review

Teaching and Learning of Mathematics through CLIL, CBI, or EMI—A Systematic Literature Review

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Abstract: This study provides a systematic literature review of research in the field of teaching and learning mathematics through Content and Language Integrated Learning (CLIL), Content-Based Instruction (CBI), and English Medium Instruction (EMI). The review aims to examine the most relevant literature with a focus on mathematics and CLIL, CBI, or EMI in Scopus and Web of Science per the Preferred Reporting Items for Systematic Reviews (PRISMA) guidelines. Based on 151 sources, 52 papers were selected according to predefined selection criteria. The papers were analysed and coded according to the following categories: (1) geographical productivity, (2) diachronic productivity growth, (3) main objectives, (4) methodology, and research design, (5) variables and measurement instruments, (6) context and sample details, and (7) main findings. The results reveal that most of the research analysed has been carried out in the Asian continent, followed by Europe. The analysis of diachronic productivity shows that the study of the application of CLIL, CBI, and EMI programs in the teaching-learning process of mathematics has notably increased in recent years, especially in the last triennium (2020–2022). Regarding the objectives of the selected corpus, the majority aimed at teaching practices and learning processes, and outcomes in mathematics and language proficiency in CLIL, CBI, and/or EMI classrooms. The corpus analysed fits within one or more of the following categories: empirical, qualitative, descriptive, correlational, and cross-sectional. The samples utilized in different studies differ significantly, both in terms of quantity –ranging from one person to 700– and in the educational level being studied, which would be primary, secondary, or tertiary education. The main variables studied in the corpus focus on mathematical competence, language proficiency, teaching practices, teacher training, science competence, and teachers' perceptions. The most widely used instruments have been objective tests, such as questionnaires, together with standardized tests to measure some aspects related to mathematical competence and language proficiency. They are followed by an analysis of documents (academic records, teaching materials, official documents...), participant or non-participant observation, interviews, and video and audio recordings. In summary, in the scientific literature analysed, a positive or neutral view predominates on the effects of the CLIL, CBI, and EMI approaches on the learning of mathematics and the L2. This can be due to methodological issues fundamentally related to the methodology, research design, sample, and measurement instruments. Thus, we must highlight that some of the results from the selected papers must be interpreted with caution. Taking this factor into consideration, further comparative studies on a wider scale are required to examine thoroughly the effects of CLIL, CBI, and EMI on the teaching and learning of mathematics in an L2. Besides, it is important to study in greater depth the different levels of language acquisition since the research analysed shows that these have not been sufficiently addressed in the mathematical field of knowledge.

Keywords: mathematics; foreign language learning; CBI; CLIL; EMI; systematic review

MSC: 97B50; 97C50; 97C70

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1. Introduction

Nowadays, the vast majority of educational policies in Europe and beyond consider the promotion of the learning of an additional language to be fundamental. Similarly, learning the contents of a specific academic subject such as mathematics through a foreign language has become an increasingly accepted framework in the field of education, especially in higher and secondary education stages. Thus, as English has been recognized as the international language of sciences and technology, it has turned out to be the quintessence key of bilingual policies hinged mainly upon the CLIL (Content and Language Integrated Learning), CBI (Content-Based Instruction), or EMI (English as a Medium of Instruction) educational approaches.

Stoller [1] (p. 59) conceives CBI as an umbrella term for approaches that amalgamate language and content learning aims, even if there may exist differences in the degree of importance ascribed to language and content per the type of program applied in a certain context. Therefore, following Cenoz's research [2], CBI and CLIL programs "share the same essential properties and are not pedagogically different from each other" (p. 8). The use of one term over the other is mainly due to contextual and accidental characteristics: CLIL is usually used in Europe, while CBI is the preferred term in American and Canadian contexts. Nonetheless, we must consider that this use may not always be linked to a specific context or educational stage as some countries have found difficulties when defining the type of program they are applying [3].

CLIL represents a pedagogical approach that pivots both on the learning of academic subject content and the learning of a foreign language, which is the medium of instruction for the content [4]. According to Carrió-Pastor and Bellés-Fortuño [5], even if CLIL and EMI programs share most of the common CBI pedagogical principles, there are some major differences between CLIL and EMI that we must highlight. Thus, the former is the approach used to teach both content and (foreign) language, while the latter focuses solely on the learning of contents through English, and hence the linguistic-related objective is peripheral. In addition, CLIL is most often put into effect in primary and secondary education, while EMI is mostly implemented in university and bilingual secondary schools since the level of English proficiency is often higher in these contexts. Another of the differences that these authors point out, referring to Dearden's words [3], is that EMI does not have a specific context of origin. English is envisaged as the language of education (with the geopolitical and sociocultural repercussions that this may entail), while CLIL refers to a clearly defined context of origin (i.e., Europe). Table 1 lists the main commonalities and differences between CLIL, CBI, and EMI.

Table 1. Commonalities and differences between CLIL, CBI, and EMI.

	CLIL	**CBI**	**EMI**
Term used in Europe	X		X
Term used in USA and Canada		X	X
Teaches both content and foreign language	X	X	
Focuses only on learning content through English			X
Primary and secondary educational levels	X	X	
University and bilingual secondary schools			X
Has no specific context of origin			X
Has a specific context of origin	X	X	

Source: own elaboration.

Therefore, we consider it convenient to carry out this study based on the premise that the CLIL and EMI approaches are very widespread in Europe and Spain, with the latter being one of the countries where more research on CLIL and EMI has been carried out [6].

Regarding the types of CLIL, we can distinguish [7] 'hard CLIL', consisting of a partial immersion process through which half of the curriculum is taught in another language; and 'soft CLIL' through which the teaching staff makes use of an integrated approach to languages, holistic, and often with an interdisciplinary extent for the teaching of the contents. Similarly, various forms of EMI can occur in the same country, school, and even in the same class whose characteristics can be classified based on the following criteria proposed by Richards and Pun [8]: purposes, assessment, curriculum models, the introduction of EMI, access to EMI, the English course and EMI, the EMI teacher, the English subject teacher, the EMI learner, and instructional materials. Therefore, as we have also observed in the literature, in some cases, the limits between the CLIL and EMI approaches are blurred and sometimes confusing. Thus, EMI is 'CLIL-ised' in practice, i.e., the L1 (mother tongue) is used at certain times both to attend to the learning needs of the content and linguistic students [9], as well as to respond to linguistic and cultural diversity in the face of phenomena such as multiculturalism [10–12].

Likewise, existing literature recognizes different types of bilingualism, which we highlight since they fit better with the objectives of our study, 'balanced bilingualism' in which individuals are capable of using two languages regularly; and 'unbalanced bilingualism', also known as 'dominant bilingualism,' in which individuals do not use the L2 at the same proficiency level as their L1 [13]. One fact that we must consider in this regard, according to the scholars, is that the latter is the one that prevails in most countries implementing CBI, CLIL, and/or EMI.

Among the benefits reported by the scientific literature about the bilingual teaching of mathematics is that it provides students with greater insight into language structures [14] which may have a positive impact on cognitive development and, more specifically, on metalinguistic awareness. The latter has been reported to be fundamental to the development of mathematical competence. Essentially, metalinguistic skills help bilingual students when solving mathematics word problems stimulating cognitive development and content knowledge compared to monolinguals [15,16]. Similarly, Bernardo and Calleja [17] contend that a good command of the students' linguistic and communicative competence in the language of instruction, be it L1 or L2 (first foreign language), has a direct influence on the development of mathematical competence. This complies with Cummins's critical threshold hypothesis [18] as he states that it is essential to attain a certain level of L1 and L2 before the positive effects of bilingualism are acknowledged. This requires a longer time and the right context in addition to quality instruction [19].

One of the big questions that have been raised about the implementation of the CLIL, CBI, and EMI programs is whether they promote language proficiency at the expense of learning academic content and, specifically, mathematics. In this sense, various studies [13,19,20] have criticized the premise from which CLIL, CBI, and EMI start, namely, that content learning and language learning are independent. Certainly, mathematics differs from other subjects in that it contains its own mathematical register, its own technical and academic language, which requires a certain degree of abstraction, and consequently, it embodies a challenge for students who must become familiar with it both in the L1 and the L2 to learn the content of the subject in addition to mastering the language in which it is taught. So, the type of language used in CLIL, CBI, and EMI generally differs from that brought into play in regular foreign language classrooms. This means that whereas foreign language lessons make informal interactions and face-to-face communication easier, CLIL, CBI, and EMI entail academic aspects of language proficiency. Following Cummins [18], language uttered in daily conversations (BICS—Basic Interpersonal Communication Skills) diverges from the language used in acquiring knowledge at school (CALP—Cognitive Academic Language Proficiency). CALP consists of the ability to produce complex meanings explicitly in a written or oral form employing language itself instead of intonation, gestures, and other non-verbal hints such as visual aids, and so on.

Hence, CALP requires higher cognitive demands than BICS as it is more abstract, context-reduced, and develops relatively slower than BICS in foreign language learners, which may have a negative impact on their motivation.

After having mentioned some of the benefits and challenges of teaching mathematics through CLIL, CBI, and EMI, we agree with Bermejo et al. [21] on the necessity to study in greater depth the different levels of language acquisition, as well as "assessing to what extent the development of mathematical thinking can be constrained if it is taught in an additional language or a 'non-dominant language'" [21] (p. 2).

In the same vein, some teaching practices have caught researchers' attention in the last decade concerning teaching mathematics through an L2. Thus, interaction has become an essential element in learning mathematics in bilingual and non-bilingual teaching contexts through dialogical learning among peers [22,23]. One of the most recent approaches that also assigns an essential role to interaction and goes beyond code-switching is translanguaging. It consists of making use of a strategic discourse both in L1 and L2, or even in an L3 (second foreign language), to enhance the learning of the language and the content in a natural, flexible, and dynamic way, favouring the communicative dimension of the language through speaking, listening, reading, signing, and remembering. Its positive impact on the teaching of mathematics is being reported by a growing number of investigations [12,24]. Another approach that strengthens the implementation of CLIL, CBI, and EMI is Task-Based Learning (TBL), which is recommended by the Council of Europe [25] and is also receiving positive reviews [26]. These authors have created a taxonomy of activity types based on TBL for teaching mathematics, among other subjects, suitable for primary and secondary CLIL classrooms. Abedi and Lord [27] also propose a list of possible adaptations of the linguistic register of mathematical word problems to the students' linguistic level that we have found of interest.

We find it useful to refer to some prior systematic reviews related to CLIL, CBI, and/or EMI. For instance, Graham et al.'s study [6] focuses on the language and content outcomes of CLIL and EMI although not in mathematics, but also other subjects such as natural and social sciences. However, the number of studies reviewed that specifically pertain to mathematics is limited to two. Macaro et al.'s study [28] exclusively examines EMI in higher education, with a focus on teachers' and students' beliefs, and explores whether teaching academic subjects in English as a foreign language benefits English proficiency without harming content learning. Finally, we have come across a review that delves into CLIL and EMI in the field of physical education [29]. To the best of our knowledge, no previous systematic review has solely focused on exploring mathematics learning through CLIL, CBI, and EMI, and that is the original contribution of this paper.

2. Materials and Methods

To respond to the study objective, i.e., to examine specifically the most relevant literature with a focus on mathematics and CLIL, CBI, or EMI, this work follows a quantitative and descriptive method, falling within the literature review studies, as it intends to explain the future of a line of inquiry in the international panorama of scientific research.

This research seeks to address the following questions:

- RQ1: How is geographical productivity distributed?
- RQ2: What is the diachronic productivity growth?
- RQ3: What are the objectives of the existing research?
- RQ4: What methodology and research design are used?
- RQ5: What are the variables and measuring instruments?
- RQ6: What type of population is selected?
- RQ7: What are the results of existing research?

To achieve the objectives described above and answer the research questions, we conducted a systematic review which was done per the Preferred Reporting Items for Systematic Reviews (PRISMA) guidelines [30].

2.1. Search Strategy

From January to September 2022, we developed the framework of this research. We began by defining the keywords to respond to the research objective, which were: "Mathematics", "Content and Language Integrated Learning" (CLIL), "Content Based Instruction" (CBI) and "English Medium Instruction" (EMI). Once the keywords had been selected, nine combined searches were carried out by introducing the following search equations: "Mathematic*" AND "Content Language Integrated Learning"; "Mathematic*" AND CBI; and "Mathematic*" AND "English medium instruction" in all possible fields (title, abstract and keywords) in Scopus, ERIC (Educational Resources Information Center) and in the Core Collection of the Web of Science (Science Citation Index Expandex (SCI-Expanded); Social Sciences Citation Index (SSCI); Arts & Humanities Citation Index (AHCI); Conference Proceedings Citation Index–Science (CPCI-S); Conference Proceedings Citation Index–Social Sciences & Humanities (CPCI-SSH); Book Citation Index – Science (BKCI-S); Book Citation Index–Social Sciences & Humanities (BKCI-SSH); Emerging Sources Citation Index (ESCI); Current Chemical Reactions (CCR-EXPANDED); and Index Chemicus (IC)). We reviewed all potential outcomes available to date, as these databases currently encompass the majority of research sources are widely used by researchers and experts across various fields of knowledge [31]. They were not restrictions placed on geographic location, language, year of publication, document, type, or any other criteria.

2.2. Inclusion Criteria

To obtain the analysis units that made up the final sample, the PRISMA protocol for systematic reviews [30] was followed, according to the inclusion and exclusion criteria outlined in Table 2.

Table 2. Inclusion/exclusion criteria.

Inclusion Criteria	Exclusion Criteria
(a) Papers (article and article review [including both bibliographical and systematic reviews]).	(a) Book chapters, proceedings, and other types of publications.
(b) Full text in English or Spanish.	(b) Restricted access (only abstract or incomplete text) or full text in other languages.
(c) Research on the teaching and learning of mathematics.	(c) Research not including the teaching and learning of mathematics.
(d) Implementation of CLIL, CBI, or EMI.	(d) Non-application of CLIL, CBI, or EMI (English for academic purposes or English for specific purposes).
(e) Research carried out in contexts where the use of CLIL, CBI, or EMI for the teaching of mathematics is through English as L2.	(e) Research carried out in contexts where the use of CLIL, CBI, or EMI for the teaching of mathematics is not English as L2.
(f) Research carried out in an instructional setting where the target population's L1 is not English.	(f) Research carried out in an instructional setting where the target population's L1 is English.
(g) Research that reports on applied empirical studies (quantitative, qualitative, mixed methods, and reviews).	(g) Non-empirical studies (i.e., those obtained through observation, perception, and interaction with our surroundings).

Source: own elaboration.

Until reaching the definitive corpus, we discarded, in the case of the sample rescued from Web of Science (n = 87), the references that were not papers (n = 30). Similarly, we performed this procedure in Scopus (n = 63) and ERIC (n = 51), excluding a total of 16 and 4 references respectively that did not meet the inclusion criteria regarding the type of publication. In this way, we analysed 151 references, 56 of which were excluded because they were papers found in both databases. The remaining 95 were evaluated for suitability based on their abstracts, and if there was any uncertainty, the complete text was examined. Finally, this figure was reduced to 52 (Figure 1) due to the following exclusion criteria: the full text was not in English or Spanish (exclusion criterion *b*) [32–36]; CLIL or EMI was applied in disciplines other than mathematics (exclusion criterion *c*) [32,35–60]; the immersion or bilingual program was not CLIL, CBI and/or EMI (exclusion criterion *d*) [57,61,62]; research carried out in contexts where the use of CLIL, CBI or EMI for the teaching of mathematics is not English as L2 (exclusion criterion *e*) [13,17,62–65]; research carried out in an instructional setting where the target population's L1 is English (exclusion criterion *f*) [56,66–69]; and non-empirical studies (exclusion criterion *g*) [70,71].

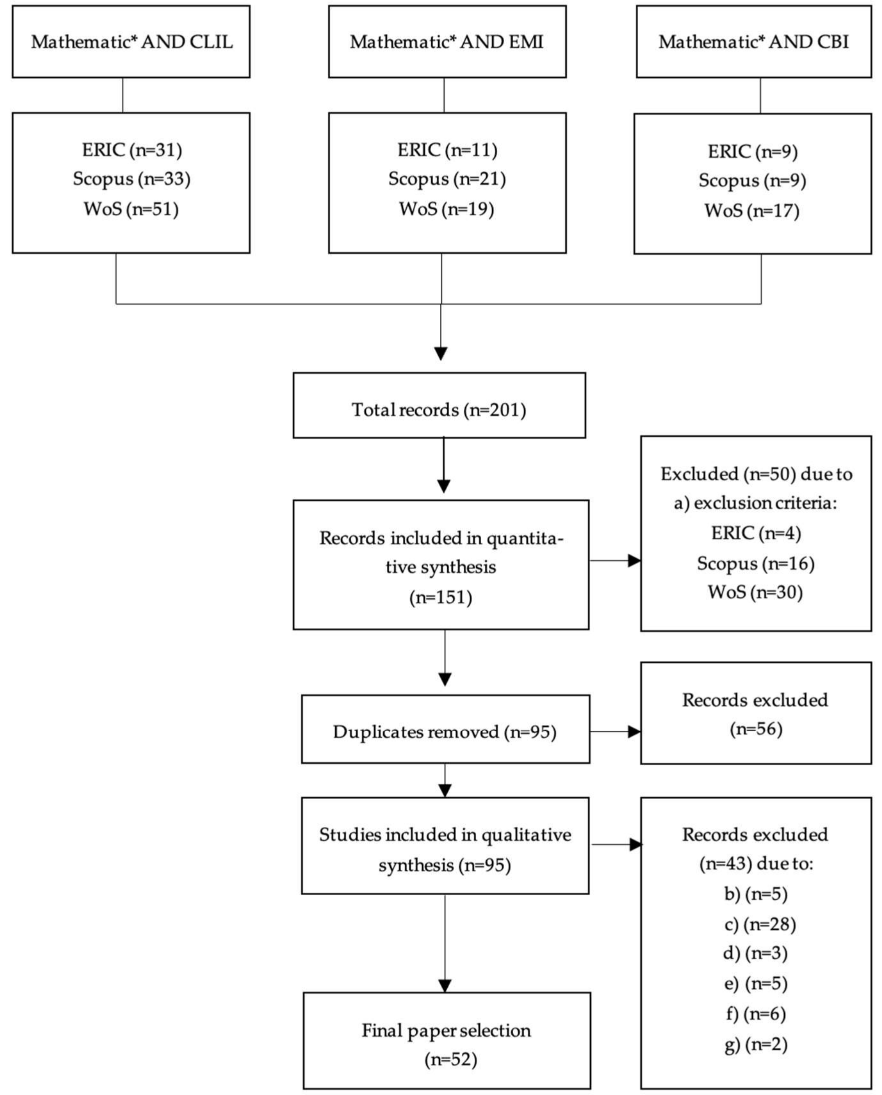

Figure 1. Flow diagram.

3. Results

Overall, 52 studies were included in the systematic review (see Appendix A): 48 applied empirical papers (92.3%) (quantitative, qualitative, and mixed methods), and four reviews of scientific literature (7.7%) [72–75]. All of them are written in English and published between 2005 and 2022.

3.1. Geographical Productivity

In terms of geographic productivity, most of the research analysed has been carried out on the Asian continent (n = 27; 51.9%) (Bangladesh 1.9%; China 13.4%; India 1.9%; Indonesia 7.6%; Iran 3.8%; Iraq 1.9%; Japan 1.9%; Malaysia 11.5%; Russia 3.8%; Thailand 1.9%), followed by the European continent (n = 24; 46.2%) (Austria 1.9%; Belgium 1.9%; Czech Republic 9.6%; Finland 1.9%; Germany 1.9%; Latvia 1.9%; Norway 1.9%; Poland 3.8%; Slovakia 1.9%; Spain 11.5%; Sweden 1.9%; Turkey 3.8%; and Ukraine 1.9%). We only found one result from the African continent (South Africa 1.9%), and none from the Americas or Oceania.

3.2. Diachronic Productivity

The analysis of diachronic productivity (Figure 2) shows that the study of the application of CLIL, CBI, or EMI programs in the teaching-learning process of mathematics has been increasing in recent years. If we analyse the total productivity, we can see that the largest number of publications is concentrated in the six years 2017–2022 (n = 35; 67.3%), with this period seeing exponential growth in research. The 2020–2022 triennium is especially noteworthy, in which a total of 21 studies are published (accounting for 40.4% of the total number of studies in this systematic review).

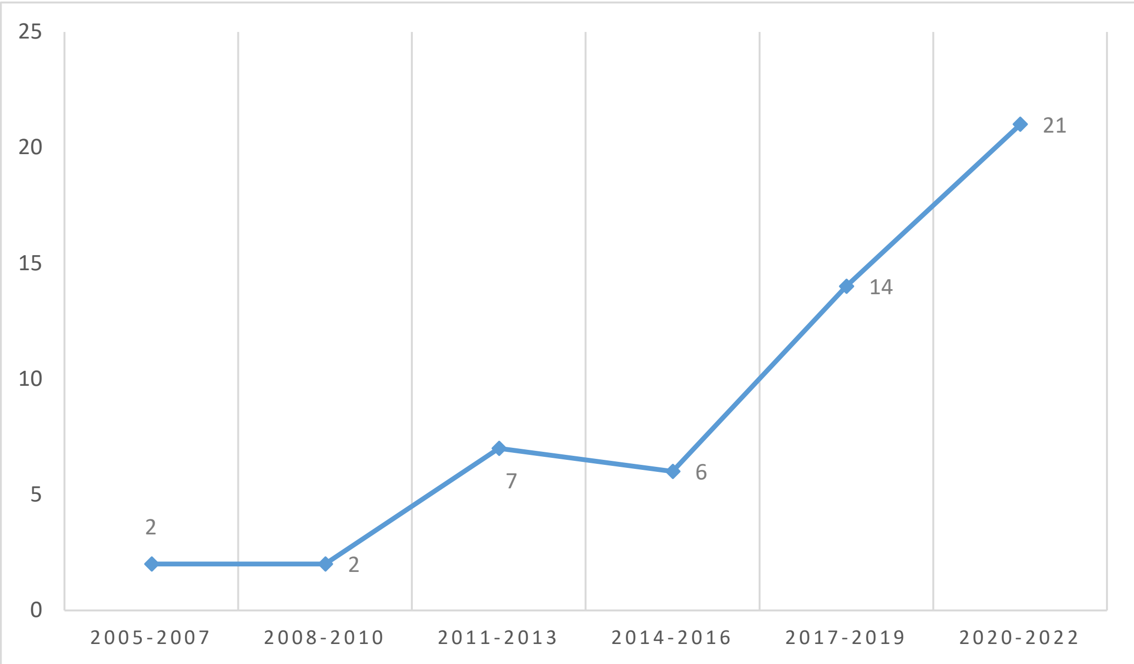

Figure 2. Diachronic productivity.

3.3. Aims

The aims of the papers included in this systematic review are diverse. On the one hand, most of the research (n = 28, 53.8%) focuses on CLIL effects on the teaching and/or learning of mathematics [11,19,21,26,73–95]. On the other hand, a smaller number of studies (n = 18, 34.6%) zero in on EMI effects on the teaching and/or learning of mathematics [10,12,96–110]. In addition, just three articles (n = 3, 5.7%) focus only on CBI without distinguishing between CLIL or EMI [111–113]. In addition, three of them (n = 3, 5.7%) address the interrelationship that is established in some contexts between the EMI and CLIL programs [9,114,115].

Similarly, we have observed that these publications spotlight the study of teaching and/or learning processes and outcomes fundamentally related to one or more of the following categories: mathematical competence (mathematical thinking, arithmetic, and problem-solving); linguistic development (linguistic skills, language proficiency, language switching, discourse competence, translanguaging, playful talk and metalinguistic awareness); cognitive development (executive functions); and digital competence. Besides, we have noticed that several investigations attempted to study mathematical competence and science competence separately without establishing connections among them [81,82,88,97,99,102,108–110]. It is worth noting that some cases fit within the framework of the STEM approach [9,76,98,101,114].

Likewise, some investigations supplement the categories described above by adding the perceptions of in-service teachers in primary [88,96], secondary education [12,85,93,103–105,108,109,113,115,116], and tertiary education [94,101,110]. Concerning the latter, we have also detected research at the tertiary level whose objective is to examine STEM (Science, Technology, Engineering, and Mathematics), EMI lecturers' perceptions about translanguaging [101], and the assessment of the four language skills of university students [110]. It is worth highlighting two studies focusing on students' perceptions, such as the mixed-method research of Rethinasamy, Chuah & Hashim [102] that centres on elementary students' perceptions about learning mathematics and science through EMI; and the quantitative research of Akbarov, Gönen & Aydogan [91] that focuses on university students who learned mathematics through a CLIL program.

On the other hand, a smaller number of investigations aim to inquire into STEM lecturers' beliefs and identities concerning the English Language Teaching (ELT) gaze [9,114], as well as secondary teachers' beliefs in mathematics following an EMI approach [96,108,109].

At the same time, we have found a few studies whose objectives revolve around the affective aspects in the teaching and learning of mathematics through CLIL, CBI, and/or EMI in all educational stages. It is noteworthy that the studies found focus solely on the teaching of mathematics through the CLIL approach. For instance, the study by Otwinowska and Foryś [83] pinpoints the relationship established between affectivity and cognitive development in CLIL mathematics in elementary classrooms. The investigation by Binterová and Šulista [78] analyses elementary school pupils' attitudes towards learning mathematics in an L2 using CLIL and an ICT tool. The paper by Akabarov, Aydogan & Gonen [91] takes into consideration CLIL university students' attitudes and preferences. Finally, the research work by Kosybayeva et al. [76] measures the psychological wellbeing of 80 university students enrolled in two mathematics and science educational CLIL courses.

Similarly, some studies concentrate on teacher training, specifically concerning: the analysis of teaching practices at secondary education [93,113] and at university [94]; the design of a proto-English syllabus using a CLIL approach for mathematics secondary teachers [87]; the implementation of a development program [80]; the restructuring of CBI mathematics university courses in Oman by using active learning through educational technology [111]; the description and discussion of a CLIL project for mathematics teaching based on TBLT [26,112]; a literature review about CLIL teaching practices in a mathematics classroom in India [75]; the implementation of a CLIL model for the learning of mathematics in English at elementary education [92]; and at university level [89,95] although from an EMI perspective [107]; and the design of a specific teaching material which is a phrasebook for English-mathematics teachers in elementary schools [100].

3.4. Methodology

The corpus analysed is primarily empirical and includes qualitative, descriptive, correlational, and cross-sectional. In terms of research design, 32.7% (n = 17) used mixed methods [11,76,78,79,83,85,87,89,92,94,95,99,100,102,107,108,111]; 30.7% (n = 16) were qualitative [9,12,26,77,80,82,90,93,96,98,103–105,110,112,116]; and 15.4% (n = 8) utilized a quantitative design [19,21,81,86,91,97,106,113,116]. Additionally, 13.5% (n = 7) were case studies [10,84,88,101,109,114,115], and 7.7% (n = 4) were scientific literature reviews [72–75].

Conversely, there were a significant number of studies with an experimental design (13.5%, n = 7) [11,19,21,78,81,92,106]. Regarding temporality, most of the studies showcased transversal results (71.2%; n = 37), while only 11.5% (n = 6) were designed longitudinally [76,78,81,106,108,111].

3.5. Main Variables and Measuring Instruments

The main variables studied in the corpus home focus on mathematical competence (100%; n = 52) and language proficiency (100%; n = 52). The presence of other variables is also significant, such as teaching practices (78.8%, *n* = 41) e.g., [65,72,78,92–96,106–109,111,112]; teacher training (55.8%; *n* = 29) e.g., [9,95,96,100,107,109,111,112]; teachers' perceptions (30.8%; *n* = 16) e.g., [94,107]; students' perceptions e.g., [91,108]; and students' attitudes e.g., [91,92]. Another representative variable is science competence (28.8%; *n* = 15) e.g., [81,82,88,97,99,102, 106]. Other variables are less well represented, such as students' vocabulary, teachers' identities, etc. (detailed information is provided in Appendix A).

To carry out the different studies, questionnaires/tests were used [11,19,21,63,76,78, 79,83,85–89,91,94,95,97–100,102,107,108,111,113] (*n* = 25; 46.2%); analysis of documents (academic record, tests or exercises...) (*n* = 22; 42.3%, e.g., [95,107,111,112]); participant or non-participant observation (*n* = 20; 38.5%) [10,12,76,78,79,84,87,88,90,94–96,103–105,108, 109,114–116]; interviews (*n* = 20; 38.5%) [9,12,78,87,88,90,94,96,99,101,103–105,107–110,114–116]; and video recordings (*n* = 9; 17.3%) [10,12,77,82,98,103–105,116]. To a lesser extent, audio recordings (*n* = 2; 3.8%) [11,84]; or focus groups (*n* = 1; 1.9%) [79] have been utilized.

3.6. Context/Sample Details

The samples utilized in different studies differ significantly, both in terms of quantity –ranging from one person to 700– and in the educational level being studied, which would be primary, secondary, or tertiary education. In this sense, most of them focus on secondary education (38.5%; *n* = 20) [11,12,77,81,82,84–87,93,103–106,108,109,112, 113,115,116]. However, a relevant number of studies are carried out in the primary education stage (19.2%; *n* = 10) [10,19,21,65,78,83,88,92,100,102], as well as at the university level (26.9%; *n* = 13) [9,76,79,89–91,94,95,97,98,101,111,114]. Additionally, regarding the population under study, some studies zoom in exclusively on students (30.8%; *n* = 16) [11,19,21,77,81,83,84,86,91,92,95,97,102,106,111,113]; pre-service teachers (3.8%; *n* = 2) [79,89]; in-service teachers (21.2%; *n* = 11) [9,85,93,94,96,98,108–110,112,114], both students and in-service teachers (25%; *n* = 13) [10,12,78,82,87,90,100,101,103–105,115,116] and others which, together with the agents already mentioned, consider other members of the educational community, such as the families or tutors of the student body (1.9%; *n* = 1) [99]. Some, however, do not carry out any field research, and their sample is made up of scientific documents or results of educational projects or programs (13.4%; *n* = 7) [26,72–75,80,88].

3.7. Main Results

As we have observed and analysed, most of the studies display positive results for the teaching and learning of mathematics and the L2 through CLIL, CBI, or EMI (*n* = 28; 53.8%) [11,12,26,73,75,78,80,81,84,85,87,90–92,94,95,99,100,102–106,110,111,113,115,116]. Moreover, papers that offer neutral results stand out (*n* = 25; 48%) [9,10,19,21,72,74,80,82,84,86,88–91,93,96,97, 101,107–110,112–114]. However, there are very few studies that present negative results (*n* = 9; 17.3%) [74,83,87,93,98,107–109,112].

The positive results correspond mainly to an improvement in mathematical competence, cognitive development, socio-cultural competence and awareness, motivation, engagement, and language proficiency in the target language (English) of the sample studied. These are supported by: teaching approaches such as task-based [26,95] and multilingual approaches [75,91]; teaching methods based predominantly on active learning [92]; language teaching strategies such as code-switching [85,115], scaffolding [90], and translanguaging [12,103,105,115,116]; and new and restructured teaching materials [26,80,87,100,106,111] including the use of ICT tools [73,92,104]. Similarly, in some cases, these results are validated/supported by the positive perceptions of learners, teachers, stakeholders, and even families about the teaching and learning of mathematics through CLIL, CBI, or EMI [12,92,94,99,102–105,110,113,116]. It is also important to refer to some studies with an experimental design that show positive effects of teaching and learning mathematics through CLIL, CBI, and EMI on students' attention, motivation, and teaching efficacy [78,92]; the highest improvements in English proficiency [11,106] and mathematical competence [11]; and faster cognitive development compared to the control group.

Neutral and negative results are especially related to:

- Age. Results from two experimental studies [19,21] demonstrate that younger students display lower effectiveness in solving verbal problem tasks in mathematics when they do it in the target language (L2) compared to the control group that learned mathematics in their mother tongue. However, these differences decreased as time progressed and exposure to the L2 increased.
- Students' low level of language proficiency [96] as well as the diversity of linguistic competence that can be present in a classroom [90]. In this sense, a study points out that previous learning of mathematical content in an L1 predicts success in EMI courses at the university level [97].
- Lack of teacher training in CLIL or CBI approaches [72,74,80,88,89,91,93,96,98,108,110,112], language proficiency [87,96,112], and ELT methods [74,82,93,96,98,108,110,112] which implies greater content teachers' language awareness [93], explicit teaching of intercultural features [84], and teacher training in classroom discourse competence [98]. A study also underlines teacher training gaps concerning teachers' skills to overcome cognitive and affective barriers that have negative effects on CLIL mathematics classrooms [72].
- Teachers' perceptions and beliefs concerning their role as merely content teachers or including that of language teachers [9,109,114], especially in EMI classrooms that have become CLIL-ised [9,114]. One of these studies emphasizes a shortage of collaboration between content and language teachers [109].
- Criticism has been directed towards top-down policies promoting CLIL, CBI, or EMI for mathematics learning, questioning their sustainability and potential for creating social disadvantages [10,101,107]

4. Discussion

The analysis of the 52 articles retrieved from Scopus, ERIC, and Web of Science has fulfilled the inclusion criteria delimited in the PRISMA review process, which has led us to the following inferences. Firstly, concerning geographic productivity, the vast majority of research on teaching and learning mathematics through CLIL, CBI, or EMI has been published in Asia and Europe, except for one study from South Africa. In the Asian continent, China (n = 7) is the country with a greater number of scientific production, followed by Malaysia (n = 5), and Indonesia (n = 4). Spain stands out as the European country with the highest number of scientific productions in this field of knowledge (n = 6), followed by the Czech Republic (n = 5). These results coincide with those produced by Macaro et al.'s [28] systematic review published in 2018 which focused on EMI in Higher Education including all disciplines (not only mathematics). Therefore, in the last 4–5 years, there has been no substantial change in terms of geographic productivity on this research focus. Other continents are very little represented such as Africa (n = 1) or are not represented at all such as America or Oceania.

Secondly, as far as diachronic productivity is concerned, we have verified that the number of studies tackling the teaching and learning of mathematics through CLIL, CBI, or EMI has experienced a dramatic increase during the last decade, in agreement with the study by Macaro et al. [28]. Since then, according to our research data, the number of papers has grown exponentially, with the greatest number of publications being found in the last six years (2017–2022), accounting for 67.3% of the research analysed in this study. More specifically, during the last triennium 2020–2022, there were 21 publications (40.4%). In this way, the foundations of this line of research have begun to be laid, providing increasingly solid knowledge in this regard. Notwithstanding this fact, to date, there is a dearth of studies in this research field aimed at comparing CLIL, CBI, or EMI effects on the mathematics teaching and learning processes and outcomes on a global scale.

Thirdly, regarding the objectives of the selected corpus, the majority of studies evaluated teaching practices and learning processes and outcomes in mathematics and language proficiency in CLIL and/or, CBI and/or EMI classrooms. It is also worth pointing out that not all the papers had the sole objective of studying mathematical competence and language proficiency in CLIL/CBI/EMI (n = 11; 27.5%). Several studies were conducted jointly with other disciplines, such as science [81,82,88,93,94,97,99,102,106–110,112,113], or within the framework of the STEM approach [9,76,98,101,114], which has become a new trend in the field of education. This suggests that these papers may not provide a very thorough analysis of the teaching and learning of mathematics since the research goals are split and shared with other disciplines such as science or technology. We believe that a greater number of studies focusing exclusively on the teaching and learning of mathematics is necessary to gain better and more quality insights into this topic. Likewise, we should consider the fact that CLIL outnumbers EMI studies. This may be because the CLIL approach has been implemented for longer and is more widely investigated than the EMI approach [5]. However, the number of publications on both programs has recently experienced a similar increase in the field of mathematics. In this sense, we cannot neglect, as Richards and Puns [8] point out, the different forms of EMI that can come together even in the same class, making it difficult to establish clear-cut boundaries between CLIL, CBI, and EMI. This has also been argued by other authors [9,114,115]. Therefore, we have been able to observe that, in addition to the aforementioned research, the objective of EMI-related studies is not solely the study of the teaching of mathematical content but that there is a clear linguistic aim under an ELT gaze [10,12,96–98,100–105,116].

Fourthly, the selected studies follow a predominantly empirical, mixed-methods, descriptive, correlational, and cross-sectional methodology. Bearing in mind the latter, the absence of a greater number of longitudinal studies that can yield more conclusive results regarding the impact of CLIL, CBI, and EMI on mathematical competence and language proficiency learning processes and outcomes, over time, is striking. Regarding the research method of the studies included, mixed-methods design (n = 17; 32.7%) prevails, followed by qualitative (n = 16; 30.7%), the latter doubling the number of purely quantitative designs (n = 8; 15.4%), case studies (n = 7; 13.4%), or literature reviews (n = 4; 7.7%). We, therefore, consider that the large body of literature is opening its scope to try to understand profoundly data from a specific context. However, it can still be difficult to determine accurately the impact of CLIL, CBI, or EMI on mathematical competence and language proficiency on a wider scale, as more quantitative studies are required in this sense. Indeed, the total number of studies including a quantitative measurement (fully or partially) does not exceed half of the selected papers (n = 25; 48%). Furthermore, we must bring to the fore the high number of experimental studies [16,19,21,63,78,81] that present methodological issues as they did not conduct a pre-test to confirm that the two groups had similar mathematical competence (content knowledge) before the intervention. In parallel, we have detected other methodological issues in the selected papers that must be addressed [6]. On the one hand, most of the CLIL, CBI, and EMI programs reviewed were electives, so they tended to attract students with greater motivation for learning a foreign language and/or higher aptitudes or previous learning outcomes. In addition, these programs offered extra instruction time, so the demonstrated benefits may simply be the result of more instruction. Furthermore, as we have been able to observe in our corpus, the participating teachers often decided to collaborate in the studies voluntarily and had years of previous experience in CLIL, CBI, or EMI. From our point of view, this factor must be considered, since it is likely that the level of quality instruction and the learning results of the students participating in the research are higher. In this respect, some important experts on CLIL and CBI [4] call attention to top-quality teaching as vital to the success of this approach.

In relation to the variables, mathematical competence (n = 52; 100%) and language proficiency (n = 52, 100%) are shared by all the studies, followed by teaching practices (n = 28; 70%), teacher training (n = 25; 62.5%), science competence (n = 15, 28.8%), and teachers' perceptions (n = 13; 32.5%). Therefore, it is remarkable that researchers are interested in determining both the benefits and the challenges of learning mathematics and, in some cases, sciences too, as well as the acquisition of the L2. They attempt to carry out successful practices that inspire training plans and models in this area. It is also key to consider their perceptions to carry out adjustments that grant validity while improving the already-mentioned practices. As for measurement, the most common instruments have been objective tests, such as questionnaires, together with standardized tests (*n* = 24; 46.2%) to gain insight into some aspects related to mathematical competence (mathematical thinking, arithmetic, and problem-solving), and language proficiency (linguistic skills, discourse competence, etc.). They are followed by an analysis of documents (academic record, teaching materials, official documents...) (*n* = 22; 42.3%), participant or non-participant observation (*n* = 20; 38.5%), interviews (*n* = 20; 38.5%), video recordings (*n* = 9; 22.5%) and audio (*n* = 2; 3.8%), and one focus group (*n* = 1; 1.95%). In general terms, according to one of the results of the study by Graham et al. [6], we have also confirmed that the research instruments are fundamentally focused on the measurement of basic interpersonal communicative skills (BICS). In this sense, we have not detected studies that opt for any specific instrument to measure cognitive academic language proficiency (CALP). However, we have noticed a growing interest in linking these two types of language through scaffolding techniques such as code-switching, the use of visual aids, multimodality, translanguaging, etc., to reduce the difficulty that comes from both the discipline itself as well as the L2 proficiency (e.g., [12,72,82,85,90,96,100–105,115,116]).

When it comes to the context/sample details, the studies analysed have been carried out mainly in the educational stages of secondary education (*n* = 20; 38.5%), university (*n* = 14; 26.9%), and primary education (*n* = 10, 19.2%). The target population under study is students (*n* = 16; 30.8%), both students and in-service teachers (*n* = 13; 25%), or in-service teachers (*n* = 11; 21.1%), while research focused exclusively on teacher trainees (*n* = 2; 3.8%) is rather scarce. One piece of information that must be taken into consideration related to the context is that not all studies specify the type of school (public, private, or others). Many also have international training plans mostly on CLIL/EMI. In addition, in general, the groups and schools in which the studies were carried out are made up of students who had previously shown a positive attitude towards learning content in another language since the latter is often part of the idiosyncrasy of the school to which both students and their families adhere to in general terms. Following Macaro et al.'s [28] results, we agree that there seems to be a greater interest in comparing the teaching-learning results of mathematics in L2 with those of L1 in the stages of primary and secondary education. Nevertheless, since this paper [28] was released in 2018, a relevant number of studies addressing higher education have been published. However, there are not many studies that compare learning in different degrees/courses [19,21,63,73,78,81,87], nor do any of them focus on the transition between the different educational stages. Consequently, we have shown that there is a lack of comparative studies between institutions and countries, especially about the education methodology for learning mathematics in an L2 through CLIL, CBI, and EMI. The single most striking observation to emerge from the data comparison was the lack of studies from other European countries where CLIL, CBI, and EMI are widely implemented (for instance, France, Italy, Switzerland, or Portugal).

Finally, regarding the main results, there are several challenges for mathematics CLIL, CBI and EMI teachers, other stakeholders, and researchers need to face according to the most relevant neutral and negative studies results which focus on:

1. All educational stages:
    - The insufficient English proficiency of mathematics content teachers and their students highlights the need to improve the CLIL CBI, and EMI policies in theory and practice, with a particular emphasis on enhancing CALP and linguistic and pedagogical abilities [87,96,97].
    - The varying levels of proficiency among students can make it challenging for mathematics and CLIL, CBI, and EMI teachers to contribute to their content and language development as highlighted in studies [74,113]. Therefore, getting support from stakeholders and even families become essential in addressing this issue.

- The challenge of finding a balance between content and language learning as well as a more flexible lesson plan and the use of time-management strategies in CLIL [74].
- The existing discrepancy between macrolevel English-only monolingual language policy adoption is encouraged by contemporary ideologies closely related to English, and micro-level stakeholders' ideologies of translanguaging and STEM pedagogy [10,101]. Regarding this, the study by Heng & Tan published in 2006 [107] warns about the kind of top-down policy that the EMI approach represents. One of the main negative impacts of this approach is the anxiety and unease it can cause in multicultural and multilingual communities, where language-related matters can trigger feelings and sensitivities associated with identity, language allegiance, power dynamics, economic benefits, ideology, and domination.

2. At primary education stage:
    - The difficulty of teaching mathematics through CLIL, CBI, and EMI in the first year of primary education affects the learning of the content such as mathematical thinking, arithmetic, and problem-solving. However, this difficulty is reduced as later courses progress [19,21,86]. This coincides with some research that suggests language proficiency is a strong predictor of mathematical academic achievement [96,106].
    - Young CLIL primary school learners may exhibit symptoms of intellectual helplessness (IH) and negative affectivity [83].
    - Traditional teaching methods for mathematics assessment in an L2 do not meet the needs of elementary school students [88].
3. At secondary education stage:
    - A lack of L2 language proficiency of CLIL [10] and EMI [112] in-service secondary teachers. In the same vein, the study by Hu & Gao [93] revealed a lack of language awareness, including the perceived role of language among four EMI secondary teachers whose pedagogical practices lacked work on English language forms and English language learning strategies.
    - The importance of devoting more instructional time to reading and writing in L2 [82], as well as teaching L2 intercultural features that may hinder the learning of some mathematical learning concepts [84].
    - Certain educational methods, such as translating and prioritizing keywords, may aid in the academic and linguistic development of students who are already proficient but can have adverse effects on the content and language acquisition of weaker students. This may also limit the development of their speaking and writing abilities [108].
    - The absence of collaboration between content and language teachers delays sustainable professional development. In this sense, the convictions of CBI secondary teachers' regarding their roles, as either solely content educators or solely language instructors can impede students' chances of acquiring language skills [109].
4. At the higher education stage:
    - Finding a balance between the four language skills in content courses can be challenging at the university level. Reading comprehension is often prioritised over listening, speaking, and writing [110].
    - Three EMI mathematics lecturers acknowledged a limited command of English and a lack of mathematical knowledge of their students [96].
    - Cognitive costs on university students caused by language switching (from L1 to L2) both in problems requiring simple fact retrieval and problems requiring knowledge application in a new context, which increases students' inhibition [96].

- The extra support and scaffolding that university students need to overcome the difficulty that learning mathematics entails concerning other subjects, even above L2 proficiency [97].
- A need for training of EMI mathematical teachers in discourse competence to promote students' motivation and classroom interaction [9,98,114].

In parallel, to some extent, we can synthesise the study's positive results on the following practical implications:

1. All educational stages:
    - Professional development programs can act as initial steps towards investigating the role of teachers in cultivating students, and mathematics-language registers within mathematics classrooms. The preparation of such professional development programs must be scrutinized in light of the existing knowledge regarding teachers' skills, especially within a curriculum that aims to merge students' language and mathematics education [80].
    - CLIL should be an essential part of mathematics and English language teacher education programs and academics should be prepared to implement CLIL in higher/tertiary education. New materials must be created for implementing CLIL at all levels of education in collaboration with mathematics and English language teachers [79].
    - In Finland, CLIL state-run schools have generally proven to provide advantageous, circumstances for mathematics and science content learning and cognitive development. In most instances, the cognitive advancement in the CLIL environments resembled that of teaching through the L1. In certain cases, the cognitive development of the experimental group appeared to be even more rapid than that of the control group [81].
    - Positive results have been obtained regarding CLIL teaching techniques and support, such as lesson planning, the use of verbal-visual-metacognitive support, and language as the means of communication [72]. The creation of specific materials adapted to a particular context and students' profiles paves the way toward successful outcomes in students' mathematics learning [100].
    - Educators ought to develop and adjust their own educational resources. However, there remains the necessity for pedagogical models that can assist them in the process. TBL is particularly compatible with a CLIL methodology and outlines a three-tier model for task creation in CLIL [26].
    - The preliminary stages for executing CLIL for prospective mathematics teachers comprise the following steps: (1) identifying the mathematics course as a foundation for implementing the combination of mathematics and English language learning; (2) selecting specific themes or units from the course; (3) outlining the expecting outcomes of the educational process; (4) creating the organizational aspects of the educational process using the CLIL methodology; and (5) developing appropriate instructional and methodological support for the integrated learning of mathematics and English, based on CLIL principles. Also, the educational process should include a special system of multilevel bilingual assignments [89].
    - The use of translanguaging as a strategy for teaching language and content is positive at all educational stages [101].
    - The use of active learning and ICT tools may contribute to quality teaching in CLIL lessons [73,111].
2. At primary education stage:
    - The age of students affects how they retrieve information when the language of instruction is different from their mother tongue in CLIL lessons [21]. Variations in mathematical performance tend to decrease over time. For example, first-grade students demonstrate lower effectiveness in solving verbal math problems in an L2, compared to second-grade students [19].

- Incorporating modern interactive ICT tools and active teaching methods in mathematics lessons creates a better educational climate than teaching the same mathematical subject matter in the L1 without the use of these tools. They have a great impact on students' motivation, activity, communication, and learning. For instance, the use of GeoGebra software has been shown to improve the effectiveness of students' learning [78,92].

3. At secondary education stage
    - The interaction between language difficulty and mathematical complexity remains at central issue in word problem-solving [80]. On the one hand, individuals who learn through the CLIL approach are more inclined to use a given text more thoroughly to systematically deduce a mathematical model compared to monolingual individuals. On the other hand, mathematical activities can result in more rigorous language usage. Proficiency in mathematics is contingent upon effective text comprehension, and problem-solving in an additional language presents additional prospects for language-based and conceptual introspection [77,84].
    - Research suggests that utilizing a CLIL approach is more effective than conventional teaching methodologies in facilitating learners' achievement of advanced levels of proficiency in the target language, as well as promoting high levels of competency in mathematics [11].
    - Code-switching can be a valuable strategy when asking for clarification, or explanation, looking for equivalence between L1 and L2 or discussing something private in CLIL lessons. It can facilitate the explanation of concepts, reduce learners' stress, and establish a positive classroom climate [85]. Other code-switching methods that teachers can use include noticing, syllabification, morphological cues, think-pair-share, vocabulary-building strategies, questioning techniques, and immediate correction [115].
    - Translanguaging can serve as a valuable tool for incorporating valuable out-of-school knowledge into the classroom, thereby aiding knowledge construction and content learning. It allows the teacher to switch between everyday language and academic register, enabling meaning-making processes to make the academic knowledge more relatable to students [103]. It also fosters an inclusive learning environment that promotes equity in knowledge construction, while also challenging the traditional hierarchical relationship between the teacher and the learner [105]. Furthermore, inclusive practices can be facilitated by translanguaging, which entails EMI teachers utilizing a range of available multilingual and semiotic resources to draw on students' collective knowledge, thereby transcending cultural boundaries in L1, L2, and even L3 contexts [12].
    - The use of the playful talk strategy can turn the classroom into a space where translanguaging is possible. This allows the teacher and students to engage in various creative acts and try out different voices to facilitate the process of making meaning and constructing knowledge [116].
    - Using ICT tools such as tablets can provide teachers with opportunities to utilize visual and spatial elements to create a technology-enhanced learning environment. This can lead to a more immersive and interactive classroom experience for students [104].
    - Learners need sizable vocabularies to cope with authentic school textbooks, especially in mathematics. Mathematics texts might be adapted by identifying and replacing low-frequency vocabulary items with high-frequency items. Besides, learning materials provided by teachers present a higher proportion of the most common vocabulary than textbooks, so they can act as a sort of lexical bridge between the classroom and the textbook [106].

4. At the higher education stage
    - Implementing a translanguaging perspective to understand university mathematics can promote a greater understanding of mathematics discourse, context, and culture [96].
    - Some methods and techniques that teachers can use to accommodate different levels of students' language proficiency include: using language scaffolding such as semantization (selecting synonyms, periphrasis, and reiteration); reducing the complexity of the instructional language; assessing students' academic achievements individually during seminars; designing their own instructional material; and selecting adapted or authentic instructional materials [90].

To sum up, in order to respond to Bermejo et al.'s [21] statement on the necessity to study in greater depth the different levels of language acquisition, the research analysed shows that these have not been sufficiently addressed in the mathematical field of knowledge (only Yakaeva et al.'s [90] study takes this into account). After analysing the selected papers, we can also affirm that most of the studies have tried to provide an answer to whether mathematical competence is hampered if taught in an L1 or an L2. As we have observed, a positive or neutral view predominates on the effects of the CLIL, CBI, and EMI approaches on the learning of mathematics and L2. This result partially converges with that offered by Graham et al. [6] who revealed that their research findings had a positive or neutral impact of CLIL and EMI on student outcomes compared to monolingual classrooms. There is also a general tendency in scientific research to offer positive results over time, but these need still to be confirmed in comparative studies on a wider scale. To date, most concerns are still teachers' and students' language proficiency, and content teachers' language awareness. Regarding this, intercultural features related to mathematics learning must be addressed. Nonetheless, teachers should pay more attention to cognitive and affective barriers. From this perspective, we agree with Sedek and McIntosh [117] in the sense that negative affectivity hinders complex cognitive processing that is crucial for problem-solving. These authors proved that experiences of failed intellectual effort may produce impaired information processing called intellectual helplessness (IH). Recent studies [83,118] suggest that this may be mainly provoked by ill-managed classes and linguistically inadequate materials too focused on CALP, which usually implies high cognitive demands reducing students' affectivity and motivation [118]. Furthermore, methodological language adaptations like using high-frequency vocabulary to the learning of mathematics are important, as well as acknowledging students' mother tongue and their L1 culture and using them to promote a positive learning climate to avoid intellectual helplessness.

5. Conclusions

After answering and discussing the questions posed at the beginning of this research, we can conclude that the study of the interrelationship established between content and L2 stands out as one of the main current questions raised by the scientific literature in this field of knowledge [RQ7]. Despite the methodological issues described above, most of the analysed research has tried to answer this question through the analysis of teaching practices that can serve as support for students to overcome the difficulty of learning both mathematics and a foreign language. These include the study of discourse competence and the subsequent use of language scaffolding, language switching, translanguaging, and playful talk, as well as the use of other visual supports and digital media that can effectively support communication, interaction, and content transmission [RQ7].

In the same vein, we consider it important to highlight the studies that relate mathematical competence and linguistic development together with cognitive development [19,21,76,77,81,83,86], describing the role that executive functions play in the learning of mathematics in L2. Among these functions, working memory, attentional control, and cognitive inhibition have been pinpointed by the research as those that are more involved in the learning processes of mathematical content in another language.

At the same time, even though great strides have been made to date, it is timely to draw attention to the scarce number of studies found in the analysed scientific literature whose objectives contemplate affective aspects related to the learning of mathematics in L2 [76,78,83,91,92]. This is essential for any type of learning [RQ3].

Likewise, we should note that positive results may have been a natural consequence of good practices and more instruction time [RQ3, RQ7]. So, we need to bear in mind some methodological issues fundamentally related to the methodology, research design, sample, and measurement instruments [RQ4, RQ5, RQ6]. Consequently, it is advisable to interpret this study's results with caution.

One of the limitations of systematic reviews is that information may have been lost due to not having used correct descriptors or due to the low feasibility of covering all the existing databases at present. We avoided too the use of the term "maths" in the search equation as it is not listed in UNESCO's thesaurus. We also considered this term as belonging to a less formal and non-academic language register. Nevertheless, we acknowledge that this might have shaped the results of the search. Another limitation that may have influenced the findings of this review is that all the papers are written in English, and we may have excluded papers in other languages that might have had important implications for the findings reported here. It is worth mentioning those references to which it has not been possible to have access and that would have enriched the results obtained in our research.

To conclude, we believe that further research is needed to investigate the effects of CLIL, CBI, or EMI on the learning of mathematics in languages other than English. Some experts have suggested that the learning of mathematics may differ depending on the intrinsic characteristics of the language in which it is taught [119,120]. Therefore, we consider that the current number of papers focused on L2s other than English is not noteworthy. In short, there is a need for more research in this field, both on a small and large scale, to determine more precisely the effects of CLIL, CBI, and EMI on the teaching and learning of mathematics in an L2 [RQ1, RQ2, RQ3, RQ4, RQ5, RQ6, RQ7].

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Appendix A

Reference, Year, Country	Aim(s)	Methodology and Sample	Main Variables	Measurement	Main Findings
Adarbah & Jajarmi, 2022, Iran [111]	To describe "the development and implementation of restructuring the teaching materials of General Foundation Program courses (basic and applied mathematics modules) in Oman by using active learning through educational technology." [111] (p. 82)	Longitudinal (2018–2020), descriptive, correlational, and mixed methods study with non-experimental design. A total of 120 university students enrolled in basic and applied mathematics modules (74 males and 46 females) ranging from 18 to 22 years of age.	Mathematical competence. Language proficiency. Teacher training. Teaching practices.	A student survey and the comparison of their exam performance across three semesters in the academic years 2018–2020 [111].	The use of active learning and educational technology significantly improved the engagement, satisfaction, and academic performance of at-risk students in the restructured courses.
Akbarov, Gönen, Aydogan, 2018, Kazakhstan [91]	To examine students' experiences, opinions, perceptions, attitudes, and preferences regarding mathematics classes where a CLIL approach was implemented.	Cross-sectional, descriptive, correlational, and quantitative study with non-experimental design. A total of 125 students from the Kazakh National University.	Mathematical competence. Language proficiency. Students' perceptions. Students' attitudes.	Ad hoc students' questionnaire.	The results showed that the participants had moderate attitudes, preferences, and satisfaction towards the CLIL approach, which used English as a medium to teach mathematics content. The students' English competences were somewhat improved, and their attitudes toward British and American culture became more positive. The participants' level of English proficiency was positively and significantly correlated with their preferences for mathematics classes and other subjects taught in English. [91]
Alhasnawi, 2021, Iraq [96]	To investigate teachers' beliefs around translanguaging (English and Arabic) in an EMI course of mathematics at tertiary level.	Qualitative study. Four EMI mathematics teachers.	Mathematical competence. Language proficiency. Teachers' beliefs. Teacher training. Teaching practices.	Semi-structured interviews. Classroom observations. Documentary analysis of Google Classroom-based teaching and assessment material.	In theory and practice, mathematics discourses are not solely centered around English but rather are more translanguaging and multi-semiotic as part of individuals' local meaning-making and knowledge-construction practices. Adopting a translanguaging perspective to understand university mathematics in this context leads to a better understanding of mathematics discourse, context, and culture. While the participants prefer using English to articulate their learning experiences and disseminate their research, they are also aware of their limited proficiency in English and that of their students in mathematics. To develop a better policy for EMI in theory and practice, it is essential to conduct serious research on developing academic language (English) and pedagogical skills specific to discipline-specific literacy practices.
Altay et al., 2022, Turkey [97]	To investigate academic achievement in EMI mathematical, physics, life sciences, and social sciences courses (MPLS) at a public university in Turkey. To examine "students' test score data on EMI and Turkish medium instruction (TMI) courses as well as general English proficiency score." [97] (p. 117)	Cross-sectional, descriptive, correlational, and quantitative study with non-experimental design. A total of 357 university students from MPLS courses. A total of 359 university students from social sciences courses.	Mathematical competence. Language proficiency. Science competence. Competence in social sciences.	Final course scores. Cambridge Preliminary English Test (PET) at the B1 difficulty level.	English language proficiency was a significant predictor of academic achievement among social science participants, whereas success in TMI courses predicted the EMI success of MPLS participants. These findings support the idea that social science students require more language support, while MPLS students should prioritize learning some content through TMI. Policies should be tailored to the specific needs of each academic discipline.
Bairy, 2019, India [75]	"To conduct comprehensive literature research on the contributing linguistic factors to 'Conceptualization in mathematics'. To illustrate the specific educational practices that support the teaching of mathematics vocabulary in a multilingual set up in India." [75] (p. 73)	Literature review.	Mathematical competence. Language proficiency. Teaching practices.	Data sources (published papers focusing on the teaching of mathematics through CLIL in the Indian context mainly).	This paper highlights positive effects on mathematics competence, cognitive development, sociocultural competence, and language proficiency resulting from the use of a multilingualism approach in mathematics classrooms in India. Specific strategies for teaching mathematics vocabulary are also discussed.
Berger, 2015, Austria [77]	To describe "the interaction between mathematics and language based on an analysis of how individual learners solve word problems in English as a Foreign Language." [77] (p. 285). To explore how the foreign language (L2) influences mathematical thinking and learning in the process of solving word problems.	Qualitative study A total of 29 learners from sixth grade (aged from 11 to 12 years old) from a secondary school.	Mathematical competence. Language proficiency. Cognitive development.	Video-records. Seventeen tasks representative of the target level in mathematics.	CLIL learners tend to use the provided text more extensively for stepwise deduction of a mathematical model. Conversely, mathematical activity can lead to more intense language activity. Successful mathematical activity relies on effective text reception, and problem-solving in a second language provides additional opportunities for reflection, both linguistically and conceptually.
Bermejo, Ester & Morales, 2021, Spain [21]	To examine the impact of the language of instruction on the mathematical thinking development of young learners because of using a language of instruction different from the student's mother tongue (L1).	Cross-sectional, descriptive, correlational, and quantitative study with experimental design. A total of 169 early ages (from 7 to 8 years old) bilingual students from first and second grades studying in international schools in Spain.	Mathematical competence. Language proficiency. Cognitive development.	The Raven CMP test; The Perception of Differences Test (TPD); Tema-3 (several tests used to evaluate mathematical proficiency); Tedi-Math operation subtests; twenty addition and subtraction verbal problems.	The second language is impacting the resolution of daily life problems, and students in the first grade are more competent when the language of instruction matches their L1. The instructional language is determined by the type of task performed, and age influences how information is retrieved according to the language of instruction. Differences in mathematical performance decrease over time when the language of instruction is different from the mother tongue.

Reference, Year, Country	Aim(s)	Methodology and Sample	Main Variables	Measurement	Main Findings
Binterová & Kominková, 2013, Czech Republic [92]	To demonstrate successful implementation of the CLIL method in mathematics lessons in elementary schools.	Cross-sectional, descriptive, correlational, and mixed methods study with experimental design. Pupils from grades 6 to 8 of elementary schools A total of 78 respondents underwent mathematics teaching in English. The control group consisted of 97 respondents.	Mathematical competence. Language proficiency. Students' perceptions. Students' attitudes. Teaching practices.	Questionnaire to Assess the State of Teaching in Individual Subjects and ad hoc questionnaire.	The use of a CLIL method made mathematics attractive even for those students who disliked it in the past. It produced more efficient teaching results and drew higher attention of all pupils in the class thanks to the use of specific ICT tools and active teaching methods. Students' results in mathematics did not have any negative effect after the use of the CLIL method. In this sense, it may improve the climate of teaching mathematics.
Binterová & Šulista, 2013, Czech Republic [78]	To analyse, compare and describe students' attitudes concerning the teaching of mathematics lessons in an L2 (English) through the Content and Language Integrated Learning (CLIL) approach and an ICT tool (*GeoGebra*) in three elementary schools. To describe mathematics teachers' perception of the ICT tool.	Longitudinal (2009–2011), descriptive, correlational, and mixed methods study with experimental design. A total of 243 elementary school students were from grades 5 to 8. Nine elementary school teachers.	Mathematical competence. Language proficiency. School climate. Teacher training. Teaching practices. Teaching materials. Students' attitudes. Teachers' perceptions.	School climate questionnaire. Long-term observations. Interviews.	The study found that the educational environment in mathematics lessons taught using the CLIL approach and supported by modern interactive technologies is significantly better than teaching the same subject matter in the L1 (Czech) without the use of computers or interactive technology-based tools. This approach has a significant impact on students' motivation, activity, communication, and learning. Teachers perceived the use of GeoGebra software in CLIL mathematics lessons as meaningful and effective in improving student learning.
Block & Moncada-Comas 2019, Spain [9]	To explore "how three Science, Technology, Engineering, and Mathematics (STEM) lecturers working in English-medium instruction (EMI) grapple with the prospect of self-positioning as English-language teachers" [9] (p. 1).	Qualitative study. Three STEM EMI lecturers from the University of Lleida (Spain).	Mathematical competence. Science competence. Technological competence. Engineering competence. Language proficiency. Teacher training. Teaching practices. Teachers' perceptions.	Interviews. Classroom observation. Multiple data sources (official documents, audio logs, diaries . . .).	The three lecturers resist the ELT perspective, even though the EMI policy has become CLIL-ised by default and not according to a planned approach. The lecturers align themselves with their academic disciplines, drawing on their understanding of their rights, duties, and obligations as STEM discipline-bound lecturers.
Block. 2021, Spain [114]	To examine "the emergent identities of three STEM (science, technology, engineering, and mathematics) lecturers, focusing especially on how they construct themselves regarding their disciplines and how researchers construct them as potential English language teachers" [114] (p. 388).	Three case studies of EMI STEM lecturers' identities. Three EMI STEM lecturers.	Mathematical competence. Language proficiency. Science competence. Technological competence. Engineering competence. Teachers' identities. Teachers' beliefs and perceptions. Teaching practices.	Face-to-face interviews. Classroom observation.	The three lecturers in the study strongly identify themselves as STEM discipline lecturers who happen to teach in English, rather than English language teachers. They resist the idea of being seen through the lens of ELT and focus on their academic disciplines. In their discussions about language, they tend to narrow their focus to grammar, pronunciation, and vocabulary, and overlook other aspects of pragmatics and discourse. The lecturer who is most confident and competent in English language proficiency prioritizes subject content over language teaching. The study suggests that universities should provide more support for EMI lecturers to develop their pedagogical skills in both subject content and English language teaching.
Cabezuelo and Pavón, 2019, Spain [86]	"To investigate to what extent the use of L2 in math tests influences bilingual education learners' process of word problem-solving in a mandatory secondary education school" [86] (p. 19).	Cross-sectional, descriptive, correlational, and quantitative study with non-experimental design. A total of 53 students aged from 15 to 16 years from the fourth grade of compulsory secondary education.	Mathematical competence. Language proficiency. Cognitive development.	Reading comprehension test, a standards-based assessment B1 test from the book *Cambridge English. Preliminary: Reading Parts 1–5* from *Reading and Writing Sample Set 6*. A paper-and-pencil questionnaire based on PISA and Andalusian Diagnostic Assessment Tests. [86]	The ability to solve word problems is not only influenced by the use of a second language but is also affected by the complexity of the mathematical concepts involved, regardless of the student's proficiency level in the language. Additionally, the way language difficulty and mathematical complexity interact is a crucial factor in the challenges of solving word problems.
Coxhead and Boutorwick, 2018, Germany [106]	To examine by what means vocabulary knowledge developed for native and non-native speakers of English throughout several years of study in a secondary school from an EMI context. To determine the vocabulary profiles of the learning materials and illustrative textbooks in English, mathematics, and science. To determine "what coverage does the Academic World List (AWL) provide over the learning materials and textbooks" [106] (p. 592).	Longitudinal (2009–2015), descriptive, correlational, and quantitative study with experimental design. A total of 468 students from an international high school (grades 6 to 11).	Mathematical competence. Language proficiency. Science competence. Students' vocabulary. Teaching practices.	The Vocabulary Level Test (VLT). Learning materials and textbooks were created specifically according to the research aims.	The participants of the test showed improvement across different levels of the test, even after taking the test multiple times. The non-native speakers who had low levels of English proficiency in Grade 6 showed the greatest improvement. Although learners with higher VLT scores are better equipped to handle textbooks and learning materials, non-native students can improve their vocabulary over time and potentially reduce the gap between their lexical knowledge and classroom texts. The analysis suggests that learners need a substantial vocabulary to understand authentic school textbooks, especially in mathematics and science. Adapting mathematics and science texts by replacing low-frequency vocabulary with high-frequency items may be helpful. Learning materials provided by teachers have less vocabulary burden than textbooks and contain a high proportion of high-frequency vocabulary, acting as a link between the classroom and the textbook.

Reference, Year, Country	Aim(s)	Methodology and Sample	Main Variables	Measurement	Main Findings
Dirba & Mencis, 2009, Latvia [79]	To investigate mathematics language teacher trainees' and academics' views on the implementation of CLIL in schools and higher educational institutions of Latvia.	Cross-sectional, descriptive, correlational, and mixed methods study with non-experimental design. Fifty mathematics teacher trainees of the Faculty of Physics and Mathematics. Forty-five English language teacher trainees, Faculty of Modern Languages. Forty teachers of mathematics from different parts of Latvia. Thirty teacher education program students of the Faculty of Education and Psychology and 16 academic staff members of the Faculty of Physics and Mathematics.	Mathematical competence. Language proficiency. Teacher training. Teaching practices. Mathematics pre- and in-service teachers' perceptions. Teaching materials.	A Survey questionnaire. Focus group. Participant observation. EPOSTL—A reflection tool for language teacher education.	CLIL should become an essential part of mathematics and English language teacher education programs, also academics should be prepared to implement CLIL in higher/tertiary education. New materials must be created for implementing CLIL at all levels of education in collaboration with mathematics and English language teachers.
Ester et al., 2021, Spain [19]	"To shed light on how to cope with problem-solving in bilingual educational contexts and to find out what semantic structures can make it more difficult to understand the problem, and if it differs when it is presented in the L1 and how any informal knowledge can be involved" [19] (p. 564).	Cross-sectional, descriptive, correlational, and quantitative study with experimental design. A total of 169 elementary school students from grades 1 and 2 (aged 7 to 8 years old).	Mathematical competence. Language proficiency. Cognitive development.	The Raven CMP test; The Perception of Differences Test (TPD); Tema-3 (several tests used to evaluate mathematical proficiency); Tedi-Math operation subtests; twenty addition and subtraction word problems.	The effectiveness of 1st-grade students in solving verbal problems in mathematics is lower when they use a second language compared to 2nd-grade students, whose effectiveness is higher in performing the same tasks.
Feryok, 2008, Malaysia [112]	To prepare Malay teachers to create and lead an in-service workshop for other mathematics and science teachers through a professional development program by focusing on task-based learning and teaching (TBLT) in English.	Qualitative study. Twenty in-service secondary EMI teachers.	Mathematical competence. Language proficiency. Science competence. Teacher training. Teaching practices.	Analysis of documents (five written assignments), and two sets of videotaped microteaching lessons.	The use of English to teach content to ESOL students has increased, leading to content teachers who lack language learning and teaching knowledge being placed in situations where such knowledge is necessary. A program was created to address this issue by providing content teachers with both theoretical and practical knowledge of language learning and teaching. The program aimed to increase teachers' awareness of the value of exploiting language learning potential, while also offering new techniques. By doing so, it aimed to improve teachers' confidence and alleviate concerns about English-medium instruction by offering a practical option that could be incorporated into the existing curriculum.
Genc & Yuksel, 2021, Turkey [98]	To examine "lecturers' questions in various English medium instruction (EMI) courses in a Turkish higher education (HE) setting following a social interactionist perspective" [98] (p. 1).	Qualitative study. Three mathematics lecturers. One molecular biology and genetics lecturer. Two computer engineering lecturers. One bioengineering lecturer.	Mathematical competence. Language proficiency. Science competence. Technological competence. Engineering competence. Teacher training. Teaching practices.	Video recordings of lessons.	The lecturers asked more questions in mathematics and engineering courses, and they tended to dominate the classroom discourse. EMI lecturers primarily used text-based, display, and convergent questions, which led to limited interaction in the classes. To encourage student involvement in classroom interaction, EMI lecturers need to be trained in classroom discourse competence to use questions more effectively.
Hajer & Norén, 2017, Sweden [80]	To investigate "a professional development program, gate a professional development program, 'Language in Mathematics ´, within a national program for mathematics teachers in Sweden" [80] (p. 4087).	Qualitative study. Professional development program for mathematics teachers: ´Language in Mathematics	Mathematical competence. Language proficiency. Professional development. Teachers' training. Teaching practices. Teaching materials.	Data sources (professional development program, official documents . . .).	Professional development programs can serve as a starting point for exploring the role of teachers in promoting the development of students' mathematics-language register in the mathematics classroom. When planning such programs, it is important to consider teachers' existing competencies, especially when the curriculum seeks to integrate students' language and mathematics learning.
Heng & Tan, 2006, Malaysia [107]	To examine contentious reactions to EMI Malaysian educational "policy from various interest groups, teacher trainers and classroom practitioners, and to the implementation of language education programs related to the teaching of mathematics and science" [107] (p. 306).	Cross-sectional, descriptive, correlational, mixed method study with non-experimental design. A total of 43 final-year students from the Faculty of Science and Environmental Studies at the University of Putra Malaysia.	Mathematical competence. Language proficiency. Science competence Teachers' perceptions. Teaching practices.	Questionnaires, interviews, and analysis of documents.	The policy of promoting the use of English in a multicultural and multilingual country has been implemented in a top-down manner, and its success depends on the government's political determination. However, this policy may be met with suspicion by some people who are concerned about issues related to identity, language loyalty, power relations, economic advantage, ideology, and hegemony. The English for the teaching of mathematics and Science program's strengths and weaknesses, the availability of resources, and the sociopolitical forces involved must be carefully monitored and evaluated.

Reference, Year, Country	Aim(s)	Methodology and Sample	Main Variables	Measurement	Main Findings
Hošpesová et al., 2021, Czech Republic [72]	To describe the historical and cultural background of mathematics education in the Czech Republic, including teachers' competencies for CLIL [72].	Literature review Twenty-one studies (11 focusing on pre-service teachers, 10 on in-service teachers).	Mathematical competence. Teachers' training. Teaching practices.	Data sources (selected studies published within the field of mathematics teacher education).	Studies in the Czech Republic target the skills needed to overcome cognitive and affective barriers that have a negative impact on CLIL mathematics lessons. They also focus on teaching techniques and support such as lesson planning, the use of verbal-visual-metacognitive support, and language as the means of communication.
Hu & Gao, 2020, China [93]	"To understand teachers' language-related pedagogical practices in CLIL and identify their needs for successfully delivering CLIL programs to achieve the dual goals of learning language and subject content" [93] (p. 2).	Qualitative study. Four EMI mathematics and science secondary teachers.	Mathematical competence. Language proficiency. Science competence. Teacher training. Teachers' identities. Teachers' perceptions. Teaching practices.	Lesson observations, semi-structured interviews, stimulated recall interviews, and the collection of learning materials such as textbooks and worksheets. [93]	The analysis revealed that the teachers in the study did not place much emphasis on teaching English language forms or strategies for language learning. The study identified instances when teaching these aspects could have been improved by better understanding and memorization of the language. The teachers' awareness of language, including their understanding of its role in teaching and their knowledge of language pedagogy, all influenced their language-related teaching practices. These findings highlight the importance of developing language awareness among subject teachers through CLIL teacher education programs to effectively implement CLIL programs.
Jappinen, 2005, Finland [81]	To examine Finnish mainstream L1 learners' thinking and content (in mathematics and sciences) learning processes in CLIL environments of English, French, or Swedish.	Longitudinal (2002–2003), descriptive, correlational, and quantitative study with experimental design. A total of 669 Finnish students aged 7 to 15 years old. (A total of 335 students from the experimental group, and 334 from the control one).	Mathematical competence. Language proficiency. Science competence. Cognitive development.	Mathematics and sciences tests.	Overall, CLIL environments in Finnish public mainstream L1 education have provided favourable conditions for thinking and content learning in mathematics and science. In most cases, the cognitive development in CLIL environments was similar to that of teaching through L1. In some cases, the cognitive development in the experimental group (CLIL) even seemed to be faster than that in the control group.
Kewara, 2017, Thailand [100]	To explore Thai mathematics teachers' perceptions toward the use of a phrasebook for language support.	Cross-sectional, descriptive, correlational, and mixed-methods study with non-experimental design. Twenty-five Thai mathematics teachers in elementary schools (grades 1 to 4).	Mathematical competence. Language proficiency. Teacher training. Teaching practices. Teaching materials. Teachers' perceptions. Teachers' satisfaction.	A set of survey questions.	It seems that the manual was well-received by both teachers and learners. Teachers found it useful and felt more confident in instructing in English with the help of the translated sentences. Learners felt comfortable practicing English in the mathematics classroom with the aid of the suggested sentences. The phrasebook could also be used as a reference manual for classroom language. Overall, teachers were satisfied with the components of the manual.
Kossybayeva et al., 2022, Russia [76]	To create a new teaching methodology centred on active social learning benefiting from modern approaches such as STEM education and CLIL in the context of distance learning. "To test the proposed teaching approach on students taking the mathematics teaching courses and molecular biology. To assess the level of psychological well-being of the participants in the educational process using the scale of psychological well-being questionnaire developed by Ryff" [76] (p. 1), to determine the psychological safety of the proposed pedagogical methodology [76].	Longitudinal (2020–2021), descriptive, correlational, and mixed methods study with non-experimental design. Eighty university students enrolled in two educational courses from two Russian (blinded) universities: Molecular Biology and Mathematical Analysis.	Mathematical competence. Language proficiency. Science competence. Psychological wellbeing. Cognitive development. Teacher training. Teaching practices.	The scale of psychological well-being questionnaire. Observations. Individual practical tasks.	It seems that a course focusing on teaching natural and mathematical sciences had a positive impact on the psychological well-being and learning of the participants. The course utilized an innovative methodology, which can be used as a pedagogical model for effective training courses. The assessment of the participant's psychological well-being was adapted to the educational context and can be used as a basis for developing motivational learning strategies to support students during crisis learning conditions, such as those experienced during the pandemic.
Maasum et al., 2012, Malaysia [113]	To describe "the challenges faced by teachers when they are required to teach content subjects such as science and mathematics in English. The focus of the paper is on the teacher's pedagogical skills, content knowledge, and teaching perspectives" [113] (p. 75).	Cross-sectional, descriptive, correlational, and quantitative study with non-experimental design. A total of 495 secondary school teachers in West Malaysia.	Mathematical competence. Language proficiency. Science competence. Teacher training. Teachers' perceptions. Teaching practices.	Ad hoc questionnaire.	Teachers possess sufficient knowledge of how to teach a subject (pedagogical content knowledge), which involves combining their understanding of the subject matter, instructional methods, and students' characteristics. Experienced teachers are aware of the importance of utilizing various teaching strategies and resources to enhance student learning in content-based instruction. However, teaching subjects like math and science in English can be challenging, particularly when students have different levels of proficiency. To create a positive learning environment that motivates students to enjoy learning these subjects in English and simultaneously improve their English skills, support from the school, parents, and community is necessary. Such support can facilitate the process of learning math and science in English.

Reference, Year, Country	Aim(s)	Methodology and Sample	Main Variables	Measurement	Main Findings
Mahan, Brevik & Ødegaard, 2018, Norway [82]	To analyse video recordings of CLIL lessons in science and mathematics as well as to compare this with the English language teaching in the same class.	Qualitative study. Three teachers (Science, Mathematics, and English respectively). A grade 9 CLIL class in a Norwegian public school (26 students, 14 to 15 years old).	Mathematical competence. Language proficiency. Science competence. Teachers' training. Teaching practices.	Video recordings.	Teaching science and mathematics through CLIL involved specific features that focused on combining content and language instruction. In CLIL instruction, these subjects were taught in English L2 and English was used as frequently as it was in traditional English language teaching. While CLIL teachers provided language support and ample opportunities for speaking, there were limited chances for reading and writing. The primary focus of CLIL teaching was on the subject matter itself, with in-depth explanations and challenging material.
Mirizon, Wadham & Curtis, 2019, Indonesia [94]	"To investigate how integrated content and language instruction, where English is used as the medium of instruction in teaching mathematics and science was viewed by the lecturers of the content subjects" [94] (p. 42). To examine whether it had an impact on the lecturers' classroom instructional practices [94].	Cross-sectional, descriptive, correlational, and mixed methods study with non-experimental design. Thirty-six lecturers.	Mathematical competence. Language proficiency. Science competence. Teacher training. Teachers' perceptions. Teaching practices.	A survey questionnaire, interviews, and classroom observations.	The majority of lecturers had a favourable perception of the integrated instruction of content and language, and this viewpoint influenced their classroom practices. They made adjustments to their teaching methods to accommodate the implementation of this policy.
Moore & Lorenzo, 2015, Spain [26]	To describe "a project which, in response to teachers' pleas for materials, led to the production of a significant bank of task-based primary and secondary CLIL units—including mathematics units—, for three L2s (English, French, and German) distributed to all bilingual section teachers Spain" [26] (p. 1).	Qualitative study. The TBL CLIL project was developed in southern Spain (Andalucía).	Mathematical competence. Language proficiency. Teachers' training. Teaching practices. Teaching materials.	Data sources (a designed bank of TBL CLIL materials).	CLIL content teachers require instructional design models to help them create or adapt their teaching materials. Task-Based Language Learning (TBL) is particularly suitable for CLIL instruction and provides a three-step model for designing tasks. Content teachers may encounter difficulties in certain areas when designing CLIL materials, and five key areas are highlighted as potentially problematic. Anecdotal evidence indicates that these models and suggestions are currently being utilized by both practicing teachers and teacher development programs.
Naštická 2016, Slovakia [84]	"To examine if bilingual mathematics instruction does or does not prevent learners from solving math word problems" [84] (p. 76). To identify intercultural features that might hinder the learning process [84].	Case study. CLIL instruction and problem-solving. Nine students (aged 12 to 13 years old). Lower secondary level.	Mathematical competence. Language proficiency. Teacher training. Teaching practices.	Participant observation. Audio records of lessons.	The study's findings indicate that the bilingual environment did not impede students' ability to solve math word problems. However, some students were perplexed by the use of a comma as a thousand-separator in multi-digit numbers, which hindered their learning and problem-solving abilities. This difference has been recognized as an intercultural variation that teachers must explain explicitly to students. Hence, teachers should anticipate how students will react to the different intercultural differences they may encounter.
Otwinowska & Foryś, 2017, Poland [83]	To "explore links between affectivity and cognition in upper-primary Polish children who learn mathematics and science in English." [83] (p. 1)	Cross-sectional, descriptive, correlational, and mixed methods study with non-experimental design. A total of 140 students aged 10 to 11 years old (private primary school).	Mathematical competence. Language proficiency. Affectivity. Cognitive development.	Intellectual Helplessness Scale (IHS). Attitudes Survey.	The study indicates that young learners in CLIL classes experience symptoms of intellectual helplessness (IH) and negative affectivity. The primary predictors of IH in CLIL are poor grades in science and mathematics and a negative attitude toward these subjects. However, grades in English do not significantly predict IH in CLIL, which may be due to the varying types of language needed in general English and CLIL classes. BICS is necessary for general English, while CALP is required for CLIL.
Ouazizi, 2016, Belgium [11]	To investigate the effects of CLIL on both the attainment of the subject matter (mathematics) and students' L2 proficiency (English).	Cross-sectional, descriptive, correlational, and mixed methods study with experimental design. Eleven students from a secondary school aged 16 years old (CLIL group). Twenty students from the same secondary school aged 15 to 17 years old (control group).	Mathematical competence. Language proficiency.	Ad hoc questionnaire. Audio-record of lessons. mathematical test. Teacher's continuous assessment report.	CLIL education is more effective than traditional education systems in helping learners to achieve high proficiency levels in the target language (English) and to attain high levels of competence in the subject matter (mathematics). [11]
Papaja & Wysocka-Narewska, 2020, Poland [85]	"To provide an outline of the research on code-switching in CLIL, including the use of mother tongue vs. target language by CLIL teachers, as well as teacher perception of CLIL learners' language use and language problems, attention being given to spoken and written discourse difficulties and ways of overcoming them" [85] (p. 51).	Cross-sectional, descriptive, correlational, and mixed methods study with non-experimental design. A total of 29 secondary school CLIL teachers teach geography, biology, mathematics, chemistry, physics, and history.	Mathematical competence. Language proficiency. Teacher training. Teaching practices. Teachers' perceptions.	Ad hoc questionnaire.	Nearly 90% of CLIL teachers use code-switching during their lessons, switching to Polish to help students understand difficult or unfamiliar concepts, reduce anxiety, and prevent confusion. About 83% of teachers report that their students also use code-switching during CLIL lessons, primarily through reiteration (asking for clarification and explanation) and equivalence (searching for English equivalents). Roughly 33% of teachers observe their students overusing code-switching when discussing private topics, at the beginning of their CLIL education, or during group or pair work. The use of code-switching appears to be a deliberate strategy that has positive effects, including clarifying concepts, reducing stress, and promoting a positive learning environment.

Reference, Year, Country	Aim(s)	Methodology and Sample	Main Variables	Measurement	Main Findings
Pipit, 2018, Indonesia [87]	"To design a proto-English syllabus by using CLIL approach for mathematics teachers in Indonesia to intensify their English performance in teaching" [87] (p. 47). To test mathematics teachers' English performance. To describe students' perceptions and satisfaction according to their mathematics teachers' English performance [87].	Cross-sectional, descriptive, correlational, and mixed methods study with non-experimental design. Eight teachers (including the principal, the curriculum coordinator teacher, and 6 mathematics teachers). A total of 48 secondary school students from grades 7, 8, and 9.	Mathematical competence. Language proficiency. Teacher training. Teaching practices. Students' perceptions. Students' satisfaction.	Ad hoc questionnaire. Interviews. Classroom observations. Tests. Analysis of written documents.	The results of a speaking test for teachers indicated that 80% of them were rated at a level of 20–30 on the TSE rating scale, indicating ineffective communication. Similarly, for the listening test, 75% of teachers were rated at a level of 2, which is an intermittent user level where real communication is difficult except for basic information conveyed through isolated words. Despite attempts to use English in class, students reported that teachers still used Indonesian as well. When teachers did use English, only 6.25% of students reported understanding well, likely due to unclear teacher pronunciation (54.17%). As a result, 95.82% of students were not satisfied with their teachers' answers. The target situation analysis showed that speaking was the most important skill that needed to be developed. Half of the students surveyed expressed a desire for teachers to use more English in the classroom. The deficiency analysis highlighted a gap between the desired level of English competence and the current level of competence among teachers.
Poo, 2021, South Africa [10]	To examine mathematics lessons to describe mathematical and multilingual moves between representations within Sepedi and EMI classrooms.	Multiple case studies focused on four teachers in early mathematics classrooms with different languages of instruction (Sepedi and EMI). Four elementary school teachers and their classrooms.	Mathematical competence. Language proficiency. Teacher training. Teaching practices.	Video-recordings. Observations.	The study suggests that there are differences in the way mathematical concepts are represented and communicated in classrooms that use different languages as the medium of instruction. Specifically, classrooms that use Sepedi as the medium of instruction tend to rely on "restatement" moves between oral and symbolic modes of representation, while classrooms that use English as the medium of instruction incorporate a wider range of mathematical moves between oral, concrete, iconic, and symbolic number-based modes of representation. These differences may have implications for students' understanding and development of mathematical knowledge, particularly in contexts where the language of instruction is associated with socio-economic disadvantage.
Prochazkova, 2013, Czech Republic [74]	To examine "the balance and mutual influence of the language of instruction and mathematics in the context of CLIL, Content, and Language Integrated Learning" [74] (p. 23).	Literature review.	Mathematical competence. Language proficiency. Teacher training. Teaching practices.	Data sources (published papers focusing on the teaching of mathematics through CLIL in the Czech Republic).	It is important for CLIL teacher training in the Czech Republic to focus on dual qualifications that incorporate both language and content subject methodologies. This can help to create a better balance between the content and language in CLIL lesson plans. Additionally, more attention needs to be paid to non-mathematics vocabulary and the level of English needs to be finely adjusted to suit the learners. A more flexible lesson plan that allows for customizable time management is also recommended for effective CLIL teaching.
Rahman & Singh, 2021, Bangladesh [101]	To investigate "STEM (Science, Technology, Engineering, and Mathematics) teachers' and students' language-related ideologies about translanguaging at a private university in Bangladesh where English has been adopted as an instructional medium" [101] (p. 1).	Case study. STEM teachers' and students' language-related ideologies. Six STEM lecturers and 10 students from STEM backgrounds.	Mathematical competence. Language proficiency. Science competence. Technological competence. Engineering competence. Teachers' perceptions Students' perceptions. Teacher training. Teaching practices.	In-depth interviews.	Although English has been adopted as the official language for instruction in STEM classrooms, the intentional use of translanguaging (using multiple languages) has been recognized as important for constructing knowledge, communicating, and making meaning in scientific contexts. However, this approach contrasts with the larger policy of promoting an English-only monolingual ideology, which is driven by contemporary beliefs about the importance of English. So, there is a mismatch between the macro-level policies and the micro-level stakeholders' beliefs and practices regarding translanguaging in STEM education.
Rethinasamy, Chuah & Hashim, 2012, Malasya [102]	To investigate 600 students' perceptions. They all have completed six years of primary education under the English for the Teaching of Mathematics and Science (ETeMS) policy.	Cross-sectional, descriptive, correlational, and mixed-methods study with non-experimental design. A total of 600 students from elementary schools who have completed all six years of learning Science and Mathematics in English.	Mathematical competence. Language proficiency. Science competence. Students' perceptions.	Ad hoc questionnaire.	It seems that the students in this study have a positive attitude toward learning Science and Mathematics in English. They also have a good perception of their English language abilities and see the importance of learning these subjects in English. Additionally, they prefer to learn Science and Mathematics in English or a bilingual context with Malay and English.
Reza Ghorbani, 2020, Iran [99]	To analyse the opportunities of introducing EMI for mathematics and sciences at senior high schools in Iran, according to the students, families, teachers, and stakeholders' perceptions [99].	Cross-sectional, descriptive, correlational, and mixed methods study with non-experimental design. Twelve participants were interviewed. A total of 38 students, 35 teachers, 33 parents, and 32 stakeholders participated in the pilot test.	Mathematical competence. Science competence. Language proficiency. Students, families, teachers, and stakeholders' perceptions.	Ad hoc questionnaires. Email interviews.	Most of the interviewees have supported the use of EMI for mathematics and sciences at senior high schools in Iran.

Reference, Year, Country	Aim(s)	Methodology and Sample	Main Variables	Measurement	Main Findings
Rohmah et al., 2019, Indonesia [88]	To examine recent practices of CLIL language assessment pattern when implemented by elementary school teachers in Indonesia.	Multiple case studies. Practices of CLIL in mathematics and sciences classrooms. Three Islamic Elementary Schools have an International Class Program (ICP).	Mathematical competence. Language proficiency. Science competence. Teacher training. Teachers' perceptions. Teaching practices.	Classroom observation. Interviews. Questionnaires. Analysis of documents (syllabus and lesson plan).	During the implementation of CLIL, traditional forms of assessment such as oral exams using the IRF pattern and teacher-led questioning were used. However, these methods of assessment were found to be inadequate for meeting the learning needs of pupils in CLIL classrooms. Alternative instruments can be used to assess EFL and mathematical and scientific competencies in the CLIL classroom context of primary education more comprehensively. [88]
Sawaki, 2017, Japan [110]	To examine the use of L1 and L2 as well as language use activities involving reading, listening, speaking, and writing in English in content courses including mathematics. To explore teachers' perceptions of four-skill English language assessment for student admission [110].	Qualitative study. Six faculty teachers in mathematics and earth sciences at a private university in Tokyo.	Mathematical competence. Language proficiency. Science competence Teacher training. Teaching practices.	One-on-one semi-structured interviews.	The courses taught by the participants required only reading in English, and the development of listening, speaking, and writing skills were not given much importance. However, despite the imbalance in the representation of these four skills, the participants' opinions were consistent with the proposed direction for the reform of English language assessment for university admission in Japan. Interestingly, most participants were positive about adopting a four-skill assessment.
Tai & Wei 2021, China [104]	"To explore how the use of the iPad extends the semiotic and spatial repertoires for enabling the EMI mathematics teacher to create a translanguaging space for supporting multilingual students' learning of new academic knowledge." [104] (p. 1)	Qualitative study. An EMI mathematics teacher and 18 students (aged 15 to 16 years old) from a Year 9 classroom.	Mathematical competence. Language proficiency. Teachers' perceptions. Teachers' training. Teaching practices.	Classroom observation. Video-recordings. Interviews.	The use of iPads in the classroom allows EMI teachers to make the most of the visual and spatial resources available, creating a technology-enhanced environment that promotes content teaching and a more interactive and stimulating learning experience.
Tai & Wei, 2020, China [103]	To examine "how fluid and dynamic meaning-making practices afford opportunities for teachers to bring the outside into the EMI classroom to support the students' learning of new academic knowledge, adopting a translanguaging perspective." [103] (p. 1)	Qualitative study. An EMI mathematics teacher and his 18 students from Year 9 class (aged 14 to 15 years old).	Mathematical competence. Language proficiency. Teachers' perceptions. Teacher training. Teaching practices.	Interviews. Classroom observations.	To support content learning and knowledge construction, translanguaging is utilized as a tool for incorporating relevant out-of-school knowledge into the classroom. This involves creating an integrated translanguaging space that blends the everyday living space with the EMI institutional learning space, resulting in a dynamic and engaging classroom experience. This approach not only enables teachers to switch between everyday language and academic register to aid in meaning-making processes, but also provides opportunities for them to utilize their own pedagogical, linguistic, cultural, and life experiences to make academic concepts more relatable and relevant to students' personal experiences.
Tai & Wei, 2020, China [105]	"To use translanguaging as an analytical perspective to analyse how an EMI mathematics teacher and his students co-learn in the classroom." [105] (p. 1)	Qualitative study. An EMI mathematics teacher and 18–30 students (aged 14 to 16 years old) from Years 8 and 9 classrooms.	Mathematical competence. Language proficiency. Teachers' perceptions. Teacher training. Teaching practices.	Classroom observation. Video-recordings. Interviews.	Translanguaging fosters an inclusive environment for collaborative learning that prioritizes equity in knowledge building and challenges the traditional hierarchy between the teacher and the student.
Tai & Wei, 2021, China [116]	To explore how an EMI mathematics "teacher constructs playful talk to achieve various pedagogical goals including building rapport, facilitating content explanation and promoting meaningful communication with students." [116] (p. 607)	Qualitative study. An EMI mathematics teacher and 18 students (aged 15 to 16 years old) from a Year 9 classroom.	Mathematical competence. Language proficiency. Teachers' perceptions. Teacher training. Teaching practices.	Classroom observation. Video-recordings. Interviews.	Translanguaging is an important tool that relies on various social factors, such as the teacher's personal beliefs, history, sociocultural background, and pedagogical knowledge, to promote playful talk in the classroom. This approach transforms the classroom into a translanguaging space, which enables both teachers and students to engage in creative acts and explore different voices to enhance meaning-making and knowledge construction.
Tai, 2022, China [12]	"To explore how the EMI teacher mobilises various resources to make discipline-specific knowledge accessible and cater to the different needs of all students in the classroom." [12] (p. 1)	Qualitative study. An EMI mathematics teacher and his 40 students' classroom (aged 16 years old) at a secondary school.	Mathematical competence. Language proficiency. Teachers' perceptions. Teacher training. Teaching practices.	Classroom observation. Video-recordings. Semi-structured interviews.	The implementation of inclusive practices is a form of translanguaging that necessitates EMI teachers to utilize diverse multilingual and semiotic resources and tap into students' collective knowledge to bridge cultural barriers between their everyday culture and the academic cultures of subjects such as science and mathematics.
Tan & Lan, 2011, Malaysia [108]	"To examine the perceptions and beliefs of upper secondary Math and Science teachers (MST) whose students are the first and second cohorts to learn Mathematics and Science in English." [108] (p. 5)	Longitudinal (2009–2010), descriptive, correlational, and mixed methods study with non-experimental design. A total of 733 upper secondary teachers.	Mathematical competence. Language proficiency. Science competence. Teacher training. Teachers' beliefs and perceptions. Teaching practices.	Survey questionnaires, interviews, and classroom observations.	Survey results, teacher interviews, and classroom observations indicate that teachers' perceptions and beliefs about MST (Mathematics, Science, and Technology) influence their classroom practices. The collected data reveals that exam policies, teacher perceptions, and beliefs combine to promote the use of translation and an emphasis on keywords during teaching. While these practices benefit academically and linguistically proficient students, they negatively affect the content and language development of weaker students. Moreover, such methods may improve students' content comprehension in the short term but hinder the development of their speaking and writing skills.

Reference, Year, Country	Aim(s)	Methodology and Sample	Main Variables	Measurement	Main Findings
Tan, 2011, Malaysia [109]	"To explore the beliefs of mathematics, science, and language teachers, and how these beliefs influence their pedagogical practices in content-based language instruction classrooms." [109] (p. 325)	Two case studies. Nine secondary school teachers (mathematics, science, and English language).	Mathematical competence. Language proficiency. Science competence. Teacher training. Teachers' beliefs. Teaching practices.	Interviews and classroom observations.	When teachers view themselves solely as content or language instructors, it limits their ability to provide students with optimal language learning opportunities. Classroom interactions are also influenced by factors such as exam pressure, curricular requirements, and time constraints, which have significant implications for student learning. The research findings highlight a lack of collaboration between content and language teachers and underscore the importance of sustained professional development in content and language integration for both groups of educators.
Tarasenkova et al., 2020, Ukraine [89]	To examine how to apply the integrated learning of mathematics and English by future mathematics teachers based on the CLIL model. [89]	Cross-sectional, descriptive, correlational, and mixed methods study with non-experimental design. Future mathematics teachers (number of participants not specified).	Mathematical competence. Language proficiency. Teacher training. Teaching practices.	Ad hoc students' questionnaire. Analysis of documents.	To implement the CLIL model effectively, certain preconditions and thorough preparation are necessary. The preparatory steps for future mathematics teachers include the following: identifying the mathematical course as a foundation for integrated learning of mathematics and English; selecting specific themes or units for the course; planning the anticipated educational outcomes; designing the organizational features of the educational process using the CLIL method; designing the appropriate teaching and methodological support of integrated learning of mathematics and English based on CLIL. The educational process should include a special system of multilevel bilingual assignments. [89]
Tavares, 2015, China [115]	To investigate a bilingual teacher's strategic use of the students' L1 in a mathematics L2-medium classroom in a secondary school in Hong Kong (China). [115]	Case study. Teacher's strategies use in a mathematics L2-medium classroom. A bilingual teacher and her group of 40 average-ability students in a mainstream all-girls secondary school.	Mathematical competence. Language proficiency. Teacher training. Teaching practices.	Classroom observations (video-recorded lessons). Semi-structured interviews. Artefacts.	The teacher used L1 strategically to help her students gradually adapt to the change in the language of instruction. She employed various methods similar to those used by L2 teachers, such as noticing, syllabification, morphology, think-pair-share, vocabulary-building strategies, questioning techniques, and immediate correction. The study provides insights into effective bilingual teaching strategies, which can be useful for bilingual teachers, teacher educators, policy-makers, and researchers interested in bilingualism and CLIL.
Wossala, 2015, Czech Republic [73]	To examine the use of the CLIL approach in the Czech Republic to determine the influence on students' motivation in mathematics lessons.	Literature review. Students from elementary schools, secondary schools, and universities.	Mathematical competence. Language proficiency. Students' perceptions. Teaching practices.	Data sources (selected studies published within the field of mathematics teacher education).	The CLIL approach is well-liked in the Czech Republic as an educational method, but its usage is limited due to the significant preparation requirements. However, modern technology and appropriate programs can address these challenges and integrate current educational trends such as CLIL and ICT. Many excellent language teaching applications are available that non-language teachers can use to enhance the quality of their lessons.
Yakaeva et al., 2017, Russia [90]	To describe discourse behaviour in the framework of interaction between teachers and students in CLIL mathematics classrooms at the university level. [90]	Qualitative study. A total of 125 bachelor students and five mathematics lecturers from the N. I. Lobachevsky Institute of Mathematics and Mechanics of Kazan Federal University.	Mathematical competence. Language proficiency. Teaching practices.	Classroom direct structured observation. Interviews.	Semantization, which involves selecting synonyms, using paraphrasing, and repeating information, is a popular method for explaining unknown mathematical terms in CLIL classrooms. The data shows that teachers and students use various speech strategies during the learning process, including three utterance incentives and four utterance responses that occur during teacher-student interactions. However, the varying levels of language proficiency among students can present a challenge for teachers. To address this, they employ various methods and techniques such as using only English in class, adjusting the level of instruction language, using personification to assess academic achievements, designing instruction materials, and selecting adapted or authentic instruction materials.
Yufrizal, 2021, Indonesia [95]	"To explore the effectiveness of a method of teaching English as a foreign language in Indonesian higher institutions called project-based Content Language Integrated Learning (CLIL) higher education institutions." [95] (p. 11)	Cross-sectional, descriptive, correlational, and mixed methods study with non-experimental design. A total of 88 university students.	Mathematical competence. Language proficiency. Teacher training. Teaching practices.	Pre-test, classroom observation (students' performances), and data sources (students' written productions).	Results confirmed that CLIL works well in Lampung's Higher Education Institutions.

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