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MAPPING RESEARCH ON CLIL IN BILINGUAL STEAM TEACHER EDUCATION: A BIBLIOMETRIC ANALYSIS AND IMPLICATIONS FOR TEACHER TRAINING IN VIETNAM

Châu Thị Hồng Nhự[1], Mai Thi Lê Hải[2*], Nguyễn Thị Nga[3], Lê Thị Kim Loan[4], Nguyễn Thùy Vân[5]

[1,2,4,5] Faculty of Education, Phu Yen University, Dak Lak Province, Vietnam
[3] Department of Primary Education, School of Education, Vinh University, Nghe An Province, Vietnam

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Corresponding Author: Mai Thi Lê Hải
(maithilehai@pyu.edu.vn)

ABSTRACT

In the context of digital transformation and globalization, bilingual STEAM teacher education grounded in the Content and Language Integrated Learning (CLIL) approach has emerged as a contemporary pedagogical orientation to meet the demand for high-quality human resources. This study conducts a systematic literature review of both domestic and international publications from 2010 to 2025 on CLIL–STEAM-integrated teacher education, aiming to elucidate the theoretical foundations, identify effective training models, delineate the core competencies required of bilingual STEAM teachers, and propose directions for practical implementation. An analysis of 40 high-quality studies reveals a strong pedagogical alignment between CLIL and STEAM education, as both are underpinned by constructivist principles, experiential and context-based learning, interdisciplinary competence development, and the cultivation of twenty-first-century skills. Notably, effective training models include co-teaching, sustained methodological integration, and practice-based competency-oriented training. Building upon these findings, the paper proposes a framework for applying the CLIL–STEAM model in bilingual STEAM teacher education in Vietnam, structured around four key pillars: academic, practical, technological, and international dimensions. In addition, it outlines an output competency framework for bilingual STEAM teachers. The study argues that the implementation of the CLIL–STEAM model represents not merely a pedagogical innovation in teacher education but also a strategic direction for enhancing training quality, strengthening international integration, and responding to the evolving demands of general education in the contemporary era.

KEYWORDS: Integration; STEAM; CLIL; bilingual education; teacher education.

1. INTRODUCTION

Education in the era of digital transformation and globalization is shifting from knowledge transmission toward the development of holistic learner competencies, including critical thinking, problem-solving, creativity, collaboration, and lifelong learning (OECD, 2019; World Economic Forum, 2020). At the same time, advances in artificial intelligence, online learning, and open educational resources are enabling more personalized and flexible learning environments (UNESCO, 2021). Interdisciplinary approaches—such as STEM, STEAM, and CLIL—have consequently become central, linking academic knowledge with real-world applications while fostering global citizenship and intercultural competence (Bybee, 2013; OECD, 2018).

Within this landscape, bilingual education and Content and Language Integrated Learning (CLIL) are widely recognized as effective pedagogical models, particularly in advanced education systems (Coyle et al., 2010; Eurydice, 2017). In parallel, STEAM education has emerged as a strategic priority in global reform, promoting interdisciplinary thinking, creativity, and problem-solving. Evidence suggests that STEAM, when implemented in bilingual contexts, also supports the development of academic language proficiency (English, 2016). The integration of CLIL and STEAM thus represents a promising approach, enabling learners to simultaneously develop disciplinary knowledge and language competence through experiential and problem-based learning. Importantly, CLIL is not merely teaching content in English but an integrated model in which content and language objectives are jointly designed and mutually reinforced.

In Vietnam, national policies on educational reform emphasize international integration and the enhancement of foreign language capacity. Recent initiatives, particularly the project on making English a second language in schools (2025–2035), provide a strong policy foundation for implementing bilingual STEAM education, especially at the primary level. In practice, this approach offers significant benefits in both language development and access to global scientific knowledge. However, a substantial gap remains between policy aspirations and teacher capacity. Many primary teachers lack the necessary competencies in academic English, interdisciplinary pedagogy, and CLIL-based instructional design, as current teacher education programs remain largely monolingual and insufficiently aligned with international standards.

Moreover, the absence of a standardized competency framework and systematic training pathways for bilingual STEAM teachers limits both curriculum innovation and teachers' professional adaptability. If bilingual STEAM education is confined to a limited number of institutions, it may also exacerbate educational inequalities.

Given these challenges, investigating CLIL-based models in bilingual STEAM teacher education is both timely and necessary. Such research provides a critical foundation for developing a competent teaching workforce capable of meeting the demands of educational reform and international integration in the contemporary context.

2. REVIEW OF STUDIES ON BILINGUAL STEAM TEACHER EDUCATION IN VIETNAM

In recent years, alongside the internationalization of education and the implementation of the 2018 General Education Curriculum, research on bilingual STEAM teacher education and CLIL-based approaches in Vietnam has begun to emerge as a distinct line of inquiry. This body of work aligns with the goal of developing integrated competencies in content, language, and pedagogy for the teaching workforce.

Although still limited in volume, existing studies have established an initial academic foundation, reflecting efforts to adapt advanced international training models to the Vietnamese context. For instance, Hằng and Hoa (2022) examine the management of English language teaching through a STEM-based instructional model, explicitly addressing the integration of scientific–technological content with language instruction in line with CLIL principles. Their work contributes not only pedagogically but also from an educational management perspective, informing the organization of STEM–CLIL-oriented teacher training. From a theoretical and methodological standpoint, Tuyết (2021) proposes a "soft CLIL" model integrated with STEAM in English classrooms, offering a flexible and context-sensitive adaptation of CLIL suitable for Vietnamese schools while opening pathways for STEAM integration in English teacher education.

In the domain of science teacher education, Bình and Phương (2023) evaluate a CLIL-based training model within an English-medium instruction (EMI) context, demonstrating its effectiveness in simultaneously enhancing subject-matter expertise and academic language proficiency among pre-service teachers. At the level of learner readiness, Lan and Hằng (2025) analyze Vietnamese students'

performance in English-medium education and highlight the interconnections among CLIL, STEM/STEAM, and language teacher education, providing empirical evidence for program design. At the early childhood level, Nam and Thanh (2023) emphasize the critical role of specialized teacher training and bilingual education expertise in fostering creativity and improving both communicative and academic outcomes. Similarly, a case study in Hanoi (Hằng & Hoa, 2022) reports significant gains in teachers' confidence and capacity to implement STEAM project-based learning, while also identifying practical challenges such as instructional design and post-training assessment.

Overall, several key trends can be identified: (i) a focus on project-based STEAM teacher training, particularly at preschool and primary levels; (ii) the growing adoption of CLIL approaches in both pre-service education and EMI contexts; (iii) the integration of STEAM with CLIL or "soft CLIL" to suit local conditions; and (iv) the linkage between bilingual education and the development of creativity and scientific competencies.

Despite these advances, significant gaps remain. The number of studies is still limited, unevenly distributed across educational levels, and lacking in longitudinal and comparative perspectives. In particular, research on comprehensive CLIL-based models for bilingual STEAM teacher education remains underdeveloped at both national and institutional levels.

In sum, bilingual STEAM teacher education represents a necessary and emerging direction for international integration in education. It is a promising yet underexplored field that requires greater investment from researchers, teacher education institutions, and policymakers.

3. METHODOLOGY

This study employs a Systematic Literature Review (SLR) to synthesize high-quality theoretical and empirical evidence on competency-based training for bilingual STEAM teachers within the CLIL framework, following PRISMA guidelines and international SLR standards. Data were collected from major academic databases (Scopus, Web of Science, ERIC, ProQuest, ScienceDirect, JSTOR, and Google Scholar) as well as national repositories, using structured keyword strategies related to teacher education, primary education, CLIL/bilingual education, STEAM/STEM, and competency frameworks.

A bibliometric analysis using VOSviewer was conducted on 772 publications from 2010 to 2025. After screening titles and abstracts, full-text assessment, and methodological appraisal, approximately 40 peer-reviewed, high-quality studies were selected. The selected studies were coded using NVivo and analyzed through thematic and qualitative content analysis.

The review focuses on three core themes: (i) theoretical foundations of CLIL–STEAM integration in teacher education; (ii) models of integrated bilingual STEAM teacher training, including the role of teachers and program structure; and (iii) implications for proposing a contextually appropriate training model. Based on these findings, the study develops a validated competency framework, identifies effective training models and research gaps, and provides a robust scientific basis for proposing applicable solutions for high-quality primary teacher education in Vietnam, with particular reference to Phu Yen University.

4. RESEARCH RESULTS

4.1. Data Analysis from the Scopus Database

Using the search query TITLE-ABS-KEY ("Content and Language Integrated Learning" OR "CLIL" AND "teacher education" OR "STEAM education"), the results indicate that…

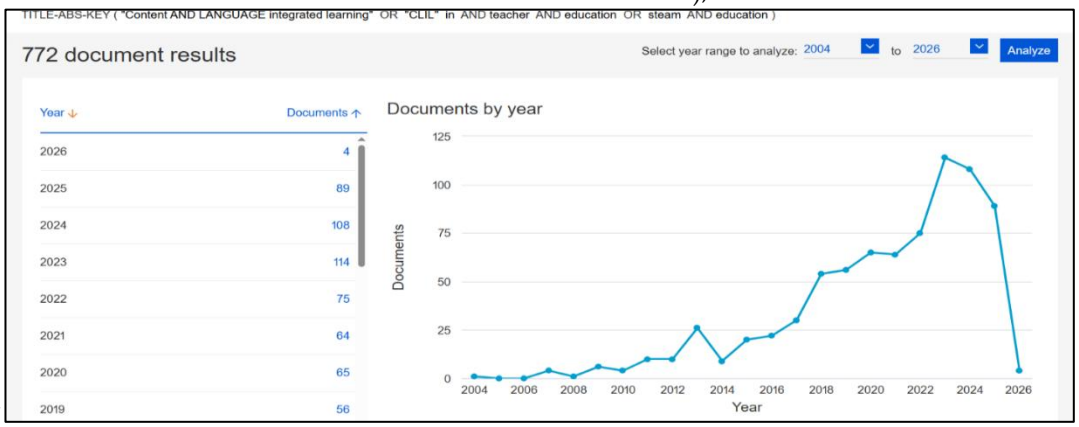

Figure 1. Documents by year on Scopus database, accessed on 16 January, 2026

The figure indicates that, over the past two decades, a total of 772 publications related to the CLIL model in bilingual STEAM teacher education have been indexed in the Scopus database. Notably, publication output has increased substantially in the last five years, reaching 64 articles in 2021, rising to 114 in 2023, and then slightly declining to 89 in 2025.

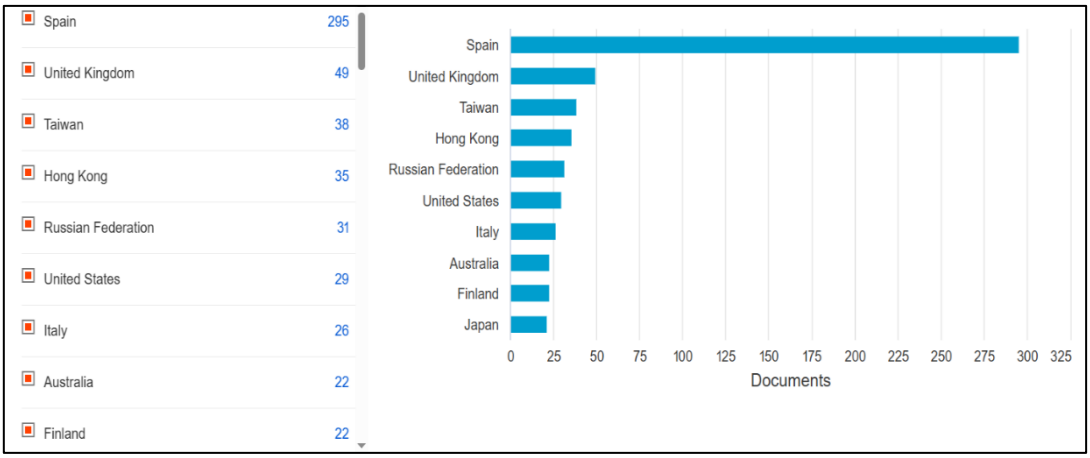

Figure 2. Documents by nation on Scopus database, accessed on 16 January, 2026

The figure shows that among the top ten countries with the highest number of publications, Spain leads in CLIL research within bilingual STEAM education, with 295 articles. Alongside the United Kingdom—where English is the native language and which has a long-standing tradition of bilingual education for second-language contexts—Taiwan and Hong Kong also stand out, with 35 and 38 publications, respectively. Russia and the United States report 31 and 29 publications, while Australia records 26. Italy and Finland each contribute 22 publications.

These findings indicate strong scholarly interest in CLIL within bilingual STEAM education across both Europe and Asia, reflecting efforts to support learners in effectively accessing globally oriented STEAM education programs.

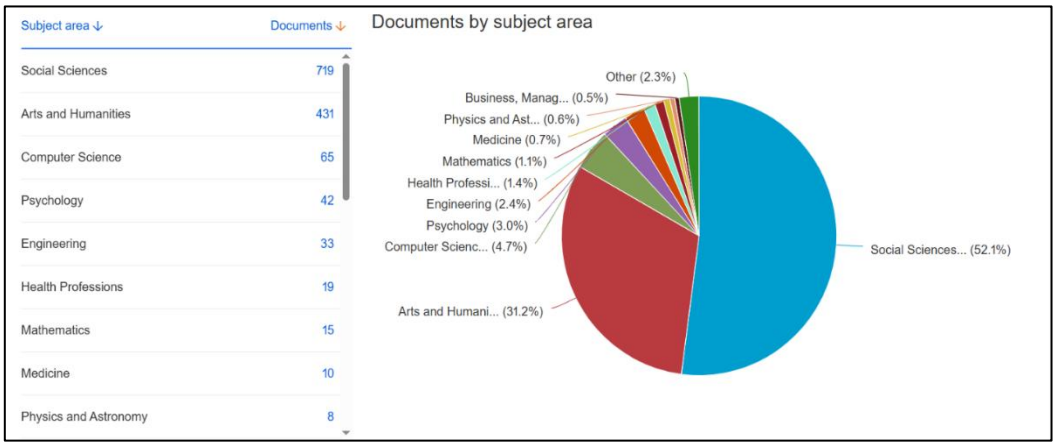

Figure 3. Documents by sunjects on Scopus database, accessed on 16 January, 2026

The chart indicates that the majority of publications fall within the field of social sciences and humanities (83.3%), while the remainder are distributed across computer science, psychology, and engineering.

4.2. Theoretical Foundations for Integrating CLIL and STEAM

4.2.1. The CLIL Pedagogical Framework

Content and Language Integrated Learning (CLIL) is grounded in multiple theoretical traditions, including communicative language teaching, task-based learning, and sociocultural theories of education. It is commonly conceptualized through the "4Cs Framework" (Content, Communication, Cognition, and Culture), which emphasizes the integration of subject content learning and language development within meaningful and authentic learning contexts (Milla, 2023; Marshalina, 2025). Empirical studies suggest that CLIL promotes deeper cognitive engagement, as learners are required to process both disciplinary knowledge and linguistic

forms simultaneously, thereby enhancing metalinguistic awareness and critical thinking (Espinar, 2025; Zhang et al., 2023).

In general education contexts, effective CLIL implementation requires age-appropriate scaffolding, the use of visual supports, and the design of multimodal learning experiences. Research indicates that successful CLIL practices at the primary level depend largely on teachers' ability to balance content and language objectives, provide comprehensible input, and create opportunities for meaningful language use (Martínez et al., 2024; Marsh & Frigols, 2008). Furthermore, the bilingual dimension of CLIL necessitates that teachers understand and strategically employ translanguaging, code-switching, and the use of learners' first language as a cognitive resource (Rojas, 2024; Mikhailovna et al., 2021).

4.2.2. Principles of STEAM Education

STEAM education extends the traditional STEM framework by incorporating the Arts, thereby foregrounding creativity, design thinking, and aesthetic dimensions of learning. Its pedagogical foundation draws on inquiry-based learning, project-based learning, problem-based learning, and maker-centered approaches (Yang, 2021). STEAM models prioritize real-world, context-rich problems that require students to integrate knowledge and skills across disciplines, fostering both depth of subject understanding and interdisciplinary breadth, as well as responsiveness to the complexity of real-life contexts (Carabelli, 2024; Stuhli et al., 2024).

4.2.3. Synergy between CLIL and STEAM

The integration of CLIL and STEAM generates strong synergistic effects for both content learning and language development. Both approaches emphasize authentic, context-based learning experiences and encourage students to engage in meaningful communication and problem-solving activities (Carrasquilla et al., 2024; Espinar, 2025). STEAM activities provide rich opportunities for language use, as learners are required to articulate observations, hypotheses, processes, and outcomes using domain-specific vocabulary and discourse (Yang, 2021; Stuhli et al., 2024). Conversely, the language-focused dimension of CLIL supports learners in expressing STEAM-related thinking, participating in collaborative inquiry, and accessing disciplinary texts and academic resources (Carabelli, 2024).

A growing body of research confirms the theoretical compatibility between CLIL and STEAM. Both are closely aligned with constructivist learning theories, emphasizing active knowledge construction, social interaction, and the development of higher-order thinking skills (Stuhli et al., 2024; Carrasquilla et al., 2024). Moreover, both frameworks aim to cultivate twenty-first-century competencies, including critical thinking, creativity, communication, and collaboration (Espinar, 2025; Yang, 2021). Accordingly, their integration in teacher education is theoretically well-founded and pedagogically promising, although it requires careful curriculum design and systematic implementation due to the increasing complexity of instructional practices (Khoiriyah et al., 2024; Milla, 2023).

4.3 Bibliometric analysis từ dữ liệu Scopus

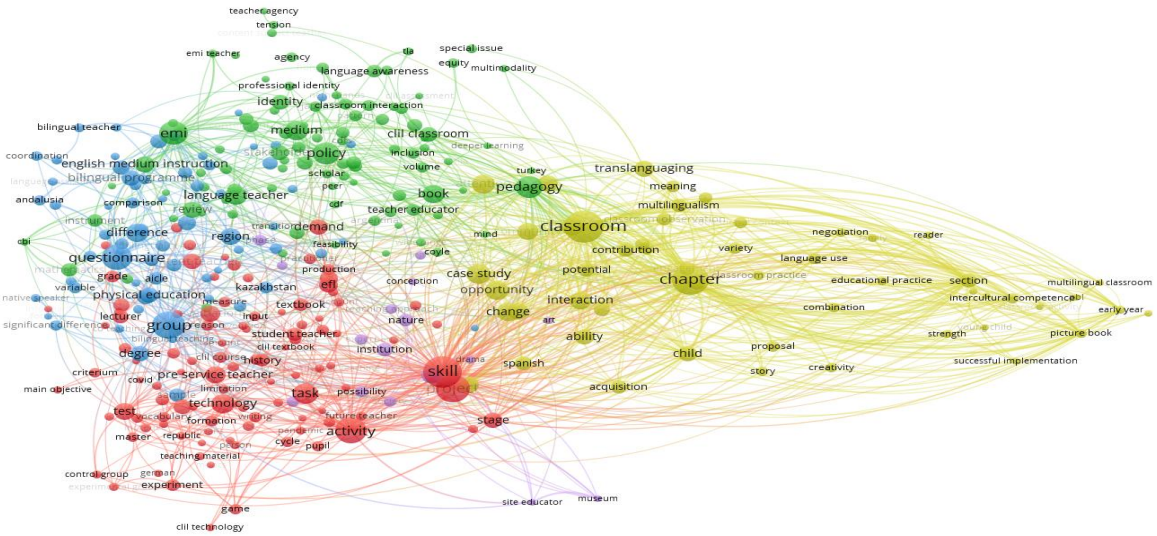

Figure 4. Bibliometric analysis based on Scopus Database and VOS viewer

4.4. Models and Approaches in CLIL–STEAM-Integrated Teacher Education

4.4.1. Co-teaching Model

In CLIL–STEAM teacher education, co-teaching is considered an advanced pedagogical structure for developing integrated competencies in content, language, and pedagogy among pre-service teachers. Co-teaching refers to a collaborative model in which two instructors with complementary expertise jointly design, deliver, and assess a course or sequence of lessons—typically involving a content specialist (e.g., mathematics, science, or technology) and a language/CLIL specialist.

Unlike parallel or translation-based instruction, co-teaching emphasizes intentional pedagogical integration, whereby STEAM content and academic language are embedded within a unified instructional design, encompassing shared objectives, activities, and assessment. Both instructors collaboratively develop lesson plans, design instructional materials, facilitate project-based and experimental learning, and support students' academic language development.

Friend and Cook (2010) conceptualize co-teaching as an equal professional partnership, in which both instructors share responsibility for student outcomes. In CLIL contexts, co-teaching operationalizes the "4Cs" framework (Content, Communication, Cognition, Culture) by directly linking disciplinary knowledge with language development (Marsh & Frigols, 2008; Martínez et al., 2024). Empirical studies indicate that co-teaching enhances pre-service teachers' capacity for integrated lesson design, bilingual pedagogy, and professional confidence. It also helps overcome barriers to interdisciplinary thinking and fosters sustainable development of integrated teaching competencies (Greca et al., 2021; Cal et al., 2022).

From a teacher education perspective, co-teaching functions not only as an instructional arrangement but also as a professional development model, addressing the fragmentation often observed between subject knowledge, pedagogy, and language competence in traditional programs.

4.4.2. Transversal Methodological Training

Another prominent approach is transversal methodological training, which emphasizes shared pedagogical principles underlying both CLIL and STEAM. Carrasquilla et al. (2024), in a quasi-experimental study with 64 pre-service teachers, compared three training models for developing CLIL lesson design competencies. The findings demonstrate that training grounded in STEM methodological principles significantly improves CLIL instructional design capacity. This suggests that helping future teachers recognize common pedagogical foundations—such as inquiry-based learning, scaffolding, and authentic assessment—may be more effective than treating CLIL and STEAM as separate approaches.

This transversal perspective is further supported by studies highlighting the importance of learner-centered pedagogy, authentic learning contexts, and holistic competency development (Espinar, 2025; Yang, 2021). By foregrounding shared methodological foundations, teacher education programs can foster a coherent and integrated understanding of contemporary pedagogies, rather than presenting CLIL and STEAM as isolated add-ons (Carrasquilla et al., 2024; Khoiriyah et al., 2024).

4.4.3. Competency-Based Training Models

A growing body of research adopts a competency-based approach to CLIL–STEAM teacher education, focusing on the identification and assessment of essential teacher competencies. Studies show that pre-service teachers often overestimate their readiness to implement CLIL, underscoring the need for practice-oriented training with continuous feedback (Khoiriyah et al., 2024). Competency-based models enable teacher educators to diagnose specific areas requiring support, such as language scaffolding, assessment design, and instructional adaptation (Milla, 2023).

Longitudinal research further indicates that structured training can significantly transform teachers' beliefs and practices—from transmission-oriented to constructivist, learner-centered approaches. Beyond knowledge and skills, competency-based models also emphasize professional dispositions and attitudes, which are critical for effective CLIL–STEAM teaching (Marsh & Frigols, 2008; Milla, 2023).

4.4.4. Practice-Based and Immersive Approaches

Practice-based and immersive approaches highlight the importance of authentic teaching experiences in CLIL–STEAM teacher education. Studies examining pre-service teachers' implementation of CLIL in primary science classrooms reveal both opportunities and challenges in translating theory into practice, emphasizing the value of supervised practicum experiences with structured feedback (Martínez et al., 2024).

Immersive training models, such as bilingual STEAM courses, provide simulated teaching environments in which pre-service teachers engage

directly with integrated content–language instruction. Evidence suggests that such approaches foster tacit knowledge and pedagogical adaptability, both of which are essential for effective CLIL–STEAM implementation. These findings reinforce the view that integrated content–language teaching is a complex, context-dependent practice that cannot be fully developed through theoretical instruction alone (Yang, 2021; Rojas, 2024).

4.4.5. International and Comparative Perspectives

The literature reveals considerable diversity in CLIL–STEAM teacher education models worldwide, reflecting variations in educational contexts and policy environments. Comparative studies highlight the influence of cultural and linguistic contexts on CLIL implementation and underscore the need for culturally responsive training models that balance local traditions with international best practices (Mikhailovna et al., 2021; Marsh & Frigols, 2008).

Policy-level reforms, such as those observed in Austria, demonstrate how systemic changes can create both opportunities and challenges for teacher education (Sappl, 2025). Across contexts, common challenges include teachers' limited confidence in foreign language proficiency and the need for practical instructional strategies. At the same time, contextual differences shape the specific pathways and effectiveness of implementation (Espinar, 2025; Zhang et al., 2023).

4.5. The Role of Teacher Competence and Self-Efficacy

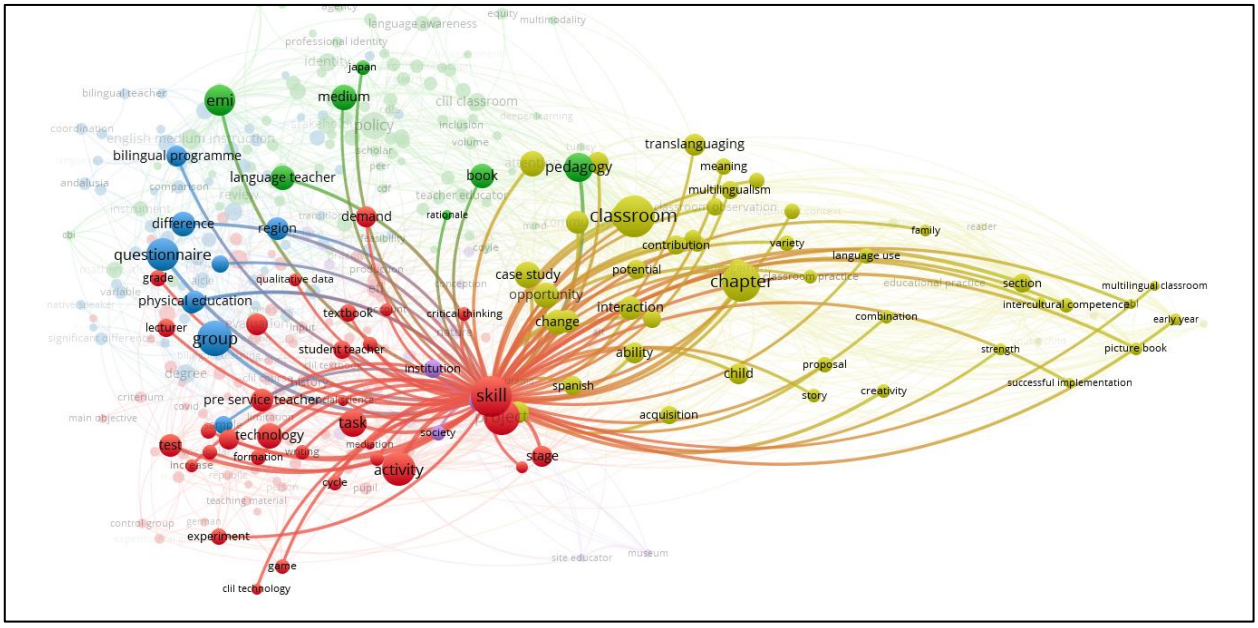

Figure 5. The Role of Teacher Quality in Implementing Bilingual STEAM Instruction

The reviewed literature consistently identifies teacher quality as a decisive factor in the effective implementation of the CLIL model in STEAM education, given that integrated instruction requires the simultaneous mobilization of subject-matter expertise, pedagogical competence, and language proficiency (Coyle, Hood, & Marsh, 2010; Mehisto, Marsh, & Frigols, 2008). CLIL–STEAM teacher competence is conceptualized as a complex construct encompassing the design of integrated content–language lessons, the provision of instructional scaffolding, the management of cognitive load, the assessment of dual learning outcomes, and the adaptation of instructional materials to diverse learner needs (Dalton-Puffer, 2011; Pérez-Cañado, 2018).

Empirical evidence indicates that pre-service teachers tend to overestimate their competence in CLIL lesson planning, particularly in areas such as language scaffolding, assessment design, and materials adaptation, thereby highlighting the importance of self-assessment and metacognitive awareness for sustainable professional development (Espinar et al., 2021). From a psychological perspective, research on teacher self-efficacy suggests that professional confidence is developed through the accumulation of knowledge, the refinement of skills, and successful classroom practice (Bandura, 1997; Khoiriyah et al., 2022).

Nevertheless, significant challenges persist, particularly in assessing integrated content–language learning, managing the increased cognitive demands of STEAM instruction, and differentiating materials for diverse learners (Dalton-Puffer et al.,

2014; Pérez-Cañado, 2016; Ruiz de Zarobe & Lasagabaster, 2010). These findings underscore that systematic investment in teacher competence development is a prerequisite for ensuring the quality and sustainability of CLIL implementation in STEAM education.

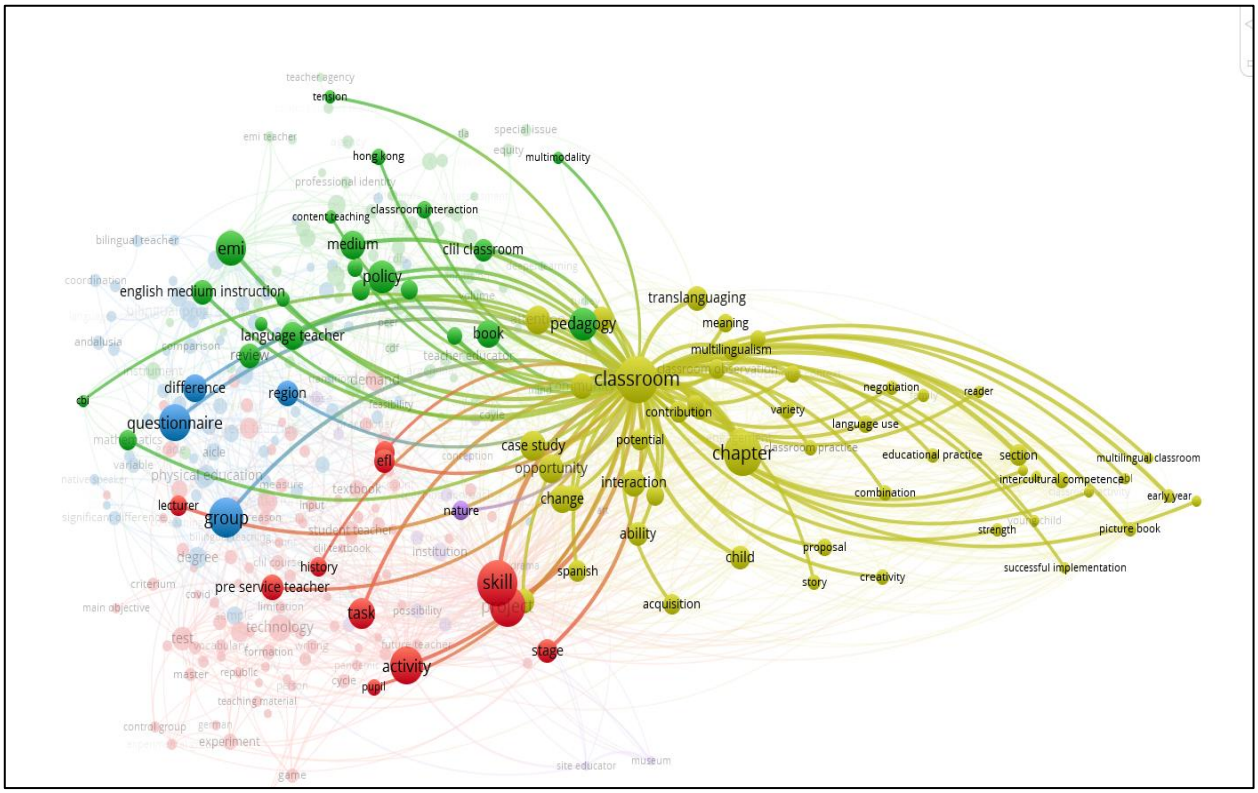

Figure 6. The Classroom as a Multifactorial Environment for CLIL Implementation

4.6. Curriculum Design

The design of bilingual STEAM teacher education programs grounded in the CLIL approach plays a pivotal role in ensuring the quality and sustainability of integrated content–language instruction. Foundational studies emphasize that CLIL–STEAM curricula should be constructed upon an integrated competency framework that systematically connects STEAM disciplinary knowledge, pedagogical expertise, and academic language proficiency (Coyle, Hood, & Marsh, 2010; Mehisto, Marsh, & Frigols, 2008). Accordingly, course syllabi must explicitly reflect the development of the four pillars of CLIL (the 4Cs: Content, Communication, Cognition, and Culture), with learning outcomes aligned to competencies such as integrated lesson design, language scaffolding, cognitive load management, and the assessment of dual learning outcomes (Dalton-Puffer, 2011; Pérez-Cañado, 2018).

Alongside curriculum design, the selection of instructional materials is critical for shaping pre-service teachers' professional competence. CLIL–STEAM materials must not only convey disciplinary knowledge but also support the development of academic language, higher-order thinking, and interdisciplinary problem-solving skills (Nikula, Dalton-Puffer, & Llinares, 2016). Empirical evidence suggests that effective programs combine internationally standardized textbooks with open educational resources, real-world case scenarios, and project-based learning models, thereby enabling pre-service teachers to engage in experiential learning, reflective practice, and the development of context-sensitive CLIL competencies (Pérez-Cañado, 2016; Ruiz de Zarobe & Lasagabaster, 2010).

In this regard, the European Framework for CLIL Teacher Education (EFCT) provides a robust reference for curriculum design, outlining key principles for professional development and ensuring a balanced integration of content, language, pedagogy, and assessment (Frigols Martín, 2011). Building on this framework, a high-quality CLIL–STEAM teacher education program should adopt an integrated structure that organically combines foundational courses in CLIL pedagogy, STEAM integration, 4C-based lesson design, dual-focused assessment, and language support strategies, alongside specialized modules in project-based learning, educational technology, and multilingual classroom management.

Pedagogical practicum constitutes a central component, enabling pre-service teachers to implement CLIL–STEAM instruction in authentic classroom settings and to develop professional competence through data-informed reflective practice. Such a structure ensures a coherent alignment between theory, practice, and professional development, representing a systematic, feasible, and sustainable model for CLIL–STEAM teacher education.

5. RECOMMENDATIONS FOR A BILINGUAL STEAM TEACHER EDUCATION MODEL AT PHU YEN UNIVERSITY

Based on international trends and local educational needs, Phu Yen University is recommended to implement a bilingual STEAM teacher education program structured around four integrated pillars: (i) an academic foundation grounded in CLIL, STEAM, and bilingual education theories; (ii) practice-oriented training through co-teaching, teaching practicum, and project-based learning; (iii) technological integration, including artificial intelligence, digital learning resources, and learning management systems; and (iv) internationalization, through English-medium instruction, global partnerships, and academic exchange.

The implementation of this model should be gradually integrated into existing teacher education programs to ensure feasibility and alignment with institutional conditions.

6. EXPECTED LEARNING OUTCOMES

The program should aim to develop core competencies among graduates, including the ability to deliver STEAM instruction in English; design and implement interdisciplinary projects; facilitate experiential learning; conduct competency-based assessment; apply educational technologies; and engage in academic communication within international contexts.

7. STRATEGIC DEVELOPMENT ORIENTATION

The adoption of the CLIL–STEAM model represents a strategic direction for positioning Phu Yen University as a reputable provider of bilingual teacher education in the South Central and Central Highlands regions of Vietnam. It also strengthens the alignment between teacher education and local educational development needs, enhances research capacity, and expands international collaboration.

In this context, the CLIL–STEAM model should be regarded as a key pillar of teacher education innovation at Phu Yen University amid digital transformation and educational internationalization. Its phased implementation is expected to enhance training quality, improve academic competitiveness, strengthen student recruitment, and establish a sustainable foundation for institutional development in the coming years.

8. CONCLUSION

The findings indicate that the pedagogical integration of CLIL and STEAM represents a highly promising approach for fostering content knowledge, language proficiency, and twenty-first-century competencies among learners. However, the successful implementation of integrated CLIL–STEAM approaches depends critically on the quality of teacher education and professional development.

Empirical evidence demonstrates that targeted training interventions—particularly co-teaching models, transversal methodological training, and practice-based learning opportunities—can substantially enhance the capacity of both pre-service and in-service teachers to implement CLIL–STEAM instruction effectively. High-quality teacher education must therefore address multiple dimensions of competence, including content knowledge, pedagogical content knowledge, language teaching expertise, curriculum design skills, technological competence, intercultural awareness, and reflective practice.

Despite these promising outcomes, significant challenges remain. Structural limitations within existing teacher education programs, gaps in instructors' knowledge and confidence, insufficient resources and institutional support, difficulties in assessing learning outcomes, and issues related to linguistic and cultural diversity continue to constrain implementation. Addressing these challenges requires coordinated efforts among teacher education institutions, schools, policymakers, and the research community.

Importantly, the integration of CLIL and STEAM should not be viewed merely as a methodological innovation, but as a fundamental reconceptualization of teaching and learning. By equipping teachers with the capacity to design and facilitate integrated, authentic, and multilingual learning experiences, teacher education programs can play a crucial role in ensuring that all learners develop the knowledge, skills, and competencies necessary to thrive in an increasingly interconnected, multilingual, and technologically complex world.

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