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Computational Thinking Integration into EFL Learning: A Systematic Literature Review

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ABSTRACT

Computational thinking (CT), a powerful problem-solving tool, knowledge acquisition optimization, and crucial skill required to engage successfully in the rapidly evolving 21st century, has been increasingly embedded into higher learning and K-12 education curricula across the globe. Since CT incorporation into English as a foreign language (EFL) education is new, the increasing research in this field remains fragmented. This study systematically reviewed 22 empirical studies published from 2015 to 2024 to provide a deeper understanding of the features and trends of CT inclusion in EFL classrooms. Employing a hybrid thematic analysis–constant comparative method across multiple databases, I mapped six EFL focus areas—academic writing, creative writing, reading, vocabulary, grammar, dialogue learning, and sentence structure—and analyzed the distribution of CT skills and cognitive-load levels. Findings demonstrate consistent, positive impacts of CT integration on learner outcomes, with academic writing leading research due to its alignment with high-load CT components such as abstraction and algorithm design. A gap analysis reveals limited teacher involvement and four main barriers: knowledge gaps, time constraints, inadequate professional development, and nascent beliefs. The article ends with some targeted recommendations for policymakers, English educators, and future research.

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INTRODUCTION

Computational thinking (CT) is not a new concept. Rooted in mid-20th century computing science, it evolved significantly in education since Alan Perlis advocated for programming literacy across disciplines in the mid-20th century (Guzdial, 2008) and Pavert's (2020) use of LOGO programming to foster procedural thinking in children. Yet, CT gained widespread academic attention after Wing (2010) redefined it as a universally applicable problem-solving skill beyond programming. (Wing, 2006) emphasized that it is not limited to language programming only; it is as a systematic, universally relevant cognitive process for designing solutions executable by humans or machines. Her framework outlines six key principles of CT. First, CT is conceptual, not limited to programming', Second, it involves flexible, abstract reasoning beyond mechanical replication. Third, it leverages human intelligence rather than mimicking computer logic. Fourth, it blends mathematical and engineering thinking. Fifth, it supports problem-solving and communication in daily life. Sixth, it is a foundational life skill, akin to literacy. These principles position CT as a cross-curricular 21st-century competency essential for learners in diverse educational contexts (Aranda & Ferguson, 2018).

The power of CT as a cross-disciplinary tool for learning and knowledge creation emerges from the possibility of applying one or a combination of its sets of cognitive and procedural skills in education. Hsu et al. (2018) synthesized 19 CT skills, including 11 originally proposed by Wing (2006). These skills span abstraction, algorithm design, data handling, decomposition, pattern recognition, simulation, and problem solving, among others. Table 1 summarizes these components and their definitions, offering a comprehensive taxonomy for instructional design and assessment.

Table 1
Taxonomy of CT Skills (Hsu et al., 2018)

No	CT Skills/Steps	Definition
1	Abstraction	Identifying and extracting the essence of a (complex) system
2	Algorithm Design	Creating an ordered instructions for solving problems or performing tasks
3	Automation	Using machines to perform repetitive tasks
4	Data Analysis	Interpreting data to find patterns or insights
5	Data Collection	Gathering relevant information
6	Data Representation	Organizing data visually or verbally
7	Decomposition	Breaking problems into manageable parts
8	Parallelization	Processing tasks simultaneously for efficiency
9	Pattern Generalization	Formulating models or rules from observed patterns
10	Pattern Recognition	Identifying trends and regularities in data
11	Simulation	Modeling real-world processes
12	Transformation	Converting information into usable formats
13	Conditional Logic	Understanding cause-effect relationships
14	Connection to other fields	Linking concepts across disciplines
15	Visualization	Enhancing understanding through visual content
16	Debug and error detection	Identifying and correcting mistakes
17	Efficiency and performance	Evaluating outcomes for optimal results
18	Modelling	Using or creating models to solve problems
19	Problem solving	Applying logical thinking to reach solutions

The opportunity for students to apply the skills to academic and real-world challenges, has resulted in its integration into curricula across K–12 and higher education worldwide (Liu et al., 2024). Initially, CT was primarily adopted by computer science and STEM disciplines due to their epistemological affinity and historical momentum. Epistemologically, CT and STEM disciplines are close to one another because CT's logic-based practices—abstraction, modeling, and algorithmic reasoning—naturally complement STEM disciplines (Li et al., 2020b). Historically, the concepts of CT proposed by Pavert (2020) and (Wing, 2006), on which CT gained traction, framed it within technological and scientific contexts. Over time, however, the appreciation for CT's capacity to scaffold critical thinking and foster creative expression across fields has been growing, expanding its integration into social sciences (Manfra et al., 2022) and humanities (Christensen, 2023)

Recent systematic reviews indicate that CT integration in STEM has reached a level of pedagogical maturity. Tariq et al. (2024), analyzing 33 studies from 2021–2024, found that CT-STEM initiatives often employ project-based, inquiry-driven, collaborative, and interdisciplinary approaches. Real-world problem contexts enhanced student engagement and highlighted CT's relevance to future careers. Similarly, Hsu et al. (2018) reviewed 116 studies from 2006–2017, noting frequent use of game-based learning alongside other pedagogies. Common tools included Scratch, Alice, LEGO robotics, board games, simulations, and digital platforms—suggesting a predominance of "plugged" approaches in CT-STEM instruction.

The reconceptualization of CT as a universally applicable thinking skill has enabled its integration into EFL education. Given CT's transdisciplinary nature, EFL educators increasingly recognize its relevance to language learning processes. Core CT skills—such as generalization, decomposition, debugging, abstraction, algorithm design, and evaluation—can scaffold writing development, including idea generation, argumentation, paragraph structuring, coherence building, and peer review. Shute et al. (2017) argue that CT mirrors scientific inquiry, making its components effective learning strategies in EFL contexts. Empirical studies have also shown that CT infusion into EFL classrooms improved reading comprehension and vocabulary acquisition (Sabitzer et al., 2018), writing (Fronza & Gallo, 2016), scriptwriting (Parsazadeh et al., 2020), and grammar knowledge and use (Youjun & Xiaomei, 2022). Yu et al.'s (2024) review reveals a positive effect of CT skills on students' EFL acquisition, grammar, and writing in particular.

Various studies have laid the groundwork for computationally enriched language instruction, including the use of Other studies investigated the use of programming (Weng & Wong, 2017; Wolz et al., 2011), educational robotics, for the same aim.

CT-EFL integration typically employs three modalities: plugged, unplugged, and hybrid. Plugged approaches leverage digital platforms to cultivate CT habits and digital fluency. Tools like Scratch (Parsazadeh et al., 2020; Weng & Wong, 2017), Alice (Durak, 2020), and educational robots (Hsu & Liang, 2021; Hsu et al., 2022), immerse learners in computing environments that enhance logical reasoning, algorithmic thinking, and systematic problem solving. Unplugged approaches use non-digital tools to teach CT concepts. Studies have revealed that they use of concept maps (Howell et al., 2011), diagrams (Sabitzer et al., 2018), and CT-infused learning strategies (Youjun & Xiaomei, 2024) could effectively support cognitive scaffolding, foster language-rich interaction, reduce tech dependency, and promote embodied learning. Hybrid approaches combine unplugged conceptual tasks (e.g., flowcharting, storytelling) with plugged digital experiences (e.g., visual programming). Hsu & Liang (2021) found that hybrid CT activities improved English proficiency and reduced language anxiety. Plugged tasks enhanced critical thinking, while unplugged ones fostered cooperation and conceptual clarity. Akiba (2022) highlights hybrid models' ability to bridge abstract logic and digital execution, supporting progressive cognitive load and deeper digital literacy.

Despite these advances, CT-EFL pedagogy remains fragmented, with diverse methodologies and contexts complicating the synthesis of best practices. Although Li et al. (2024) and Yu et al. (2024) have conducted systematic reviews of CT in language education, their focus on primary ESL contexts and mixed-language leave a gap in EFL-specific insights across educational levels. Since addressing this gap is essential for guiding curriculum innovation, teacher development, and future research, this systematic literature review (SLR), uses a hybrid content analysis–constant comparative method (CA–CCM) to examine recent empirical studies. It maps five key dimensions to provide actionable insights for curriculum design, teacher development, and future inquiry. The following research questions guide this review:

RQ1: What educational contexts integrate CT into EFL learning?
RQ2: What pedagogical approaches and methods are employed in CT integration across different educational levels and contexts?
RQ3: What EFL focuses and learner outcomes have been reported following CT integration?

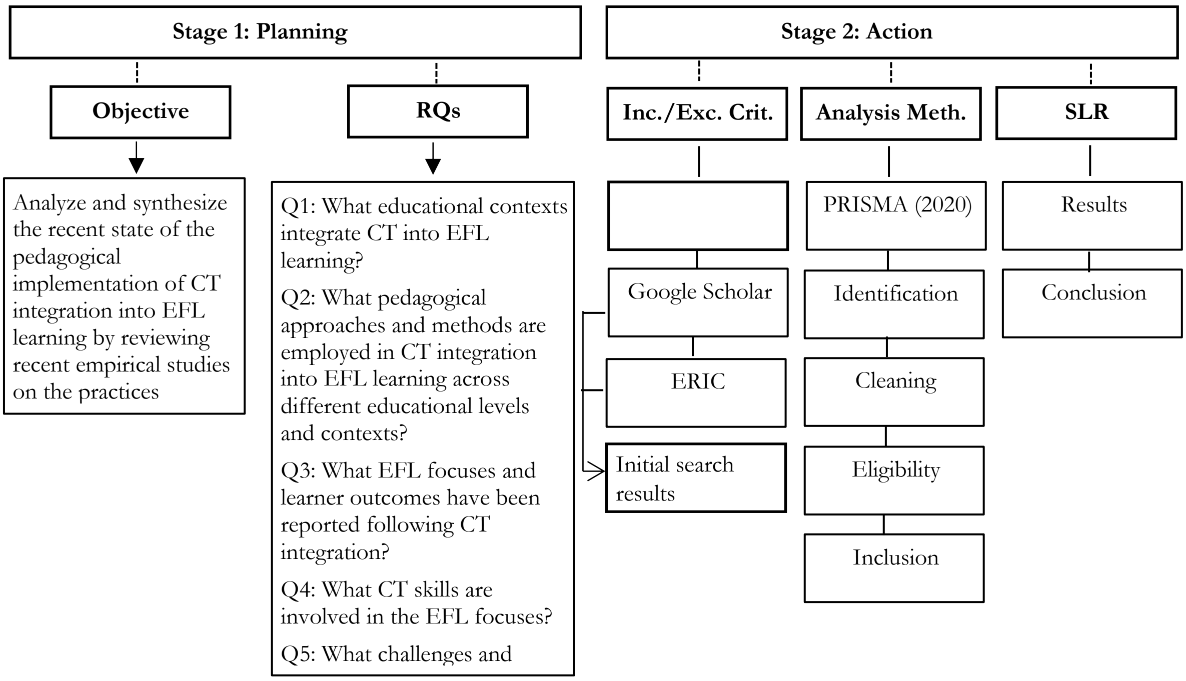
RQ4: What CT skills are most frequently integrated into EFL learning activities across the studies?
RQ5: What challenges and opportunities do educators face in implementing CT within EFL curricula?

METHOD

Review Framework

This study follows the PRISMA-P guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Protocols) to ensure transparency and rigor in protocol development and reporting (Shamseer et al., 2015). The protocol involves two stages (Vázquez-Parra et al., 2022): planning, the phase for stablishing the objectives and formulating research questions that guide literature identification and analysis, and action, the stage for executing the systematic search, screening, eligibility assessment, and final inclusion of studies. I employed the following two-stage framework (Figure 1) in this study.

Figure 1.
The two stages guiding the study (Adopted from Tariq et al., 2024)



The planning stage (Stage 1) initiates with a clear objective, i.e., to analyze and synthesize recent empirical studies on CT-EFL learning integration. It leads to the formulation of the five specific research questions, serving to direct the literature review and empirical analysis. The questions inquire about the educational contexts, pedagogical approaches and tools, EFL focuses and learning outcomes, opportunities and challenges educators meet, and research voids. I formulated each question to dissect various dimensions of the overarching research topic, ensuring a thorough exploration of the subject. Having defined the objectives and research questions, I turned to action (Stage 1) carefully structured into four phases: selecting database, determining inclusion/exclusion criteria, presenting the initial search results that suit the search queries, and determining the analysis method.

Database selection

To maximize coverage of CT-in-EFL research, I selected two complementary databases: Google Scholar (GS) and ERIC. I chose GS for its extensive indexing of academic publications and its provision of early access to emerging pedagogical studies and ERIC to complement GS due to its focus on peer-reviewed educational research, ensuring inclusion of high-quality empirical studies. Likewise, I believed their shared entries could facilitate comprehensive coverage of research on CT integration into EFL instruction.

Inclusion and exclusion criteria

Table 2 presents the criteria used to include or exclude articles from this review. The criteria helped us determine a study's eligibility based on its relevance and acceptance. I formulated the criteria grounded in the answers to two questions: Is the study relevant to the review's purpose? Is the study acceptable for review?

Table 2.

Inclusion and Exclusion Criteria

Criterion	Include ✓	Exclude ✗
Empirical CT-in-EFL studies	✓	✗
ELT studies in non-EFL settings	✗	✓
Review/synthesis articles	✗	✓
Refereed journals & proceedings	✓	✗
Pre-2016 publications	✗	✓
English-language only	✓	✗

In this study, I focused solely on empirical studies because they are evidence-based, offering methodological clarity and analytical precision. Unlike review and conceptual papers that may lead to duplication or circular referencing as they often summarize or interpret empirical work, empirical studies minimize redundancy. I took 2016 as the lower bound for two reasons. First, this review captures that empirical research on CT integration into EFL learning began to accelerate after 2015. Early conceptual papers and pilot studies appeared sporadically before 2016, but systematic investigations, robust designs, and classroom implementations gained momentum only in the mid-2010s. Second, the decade from 2016 to 2025 encompasses key milestones in CT-EFL scholarship due to the emergence of CT-TPACK frameworks that explicitly marry CT principles with language pedagogy, the widespread adoption of both digital and unplugged CT activities in EFL contexts, and the shift toward outcome-based and student-centered models that foreground CT as a cognitive toolkit for language learning.

Table 3.

Search and Screen Steps

Step	GS Records	ERIC Records	Combined Totals	Notes
Initial retrieval	475	199	674	
Duplicates removed	112†	68†	180†	Automated via Zotero
Non-journal articles	261	95	281‡	Filtered by file type in Zotero
Title/keyword screening	82	–	82	Based on GS first pass
Combined de-duplication	82	36	118	Merged in Mendeley
Irretrievable	–	–	5	Missing full texts
Full-text rescreening	–	–	79	Single reviewer
Final inclusion	–	–	22	

† Duplicates across and within databases
‡ Non-empirical or non-peer-reviewed entries

Search and Screening Procedure

To facilitate relevant scientific documents, I applied the PRISMA analysis method (Page et al., 2021) in five steps. As shown in Table 3, I initiated the retrieval by searching GS employing "computational thinking" AND "English language learning" AND "EFL" as the search terms and 2016–2025 as the timeframe on August 5, 2025. Yielding 475 records, I imported them in RIS format to Zotero to detect and delete 112 duplication and 281 non-journal articles or conference papers/proceedings. Screening the remaining 93 records based on title and keywords to ensure they were research articles; I finally got 82 documents and saved them in Mendeley.

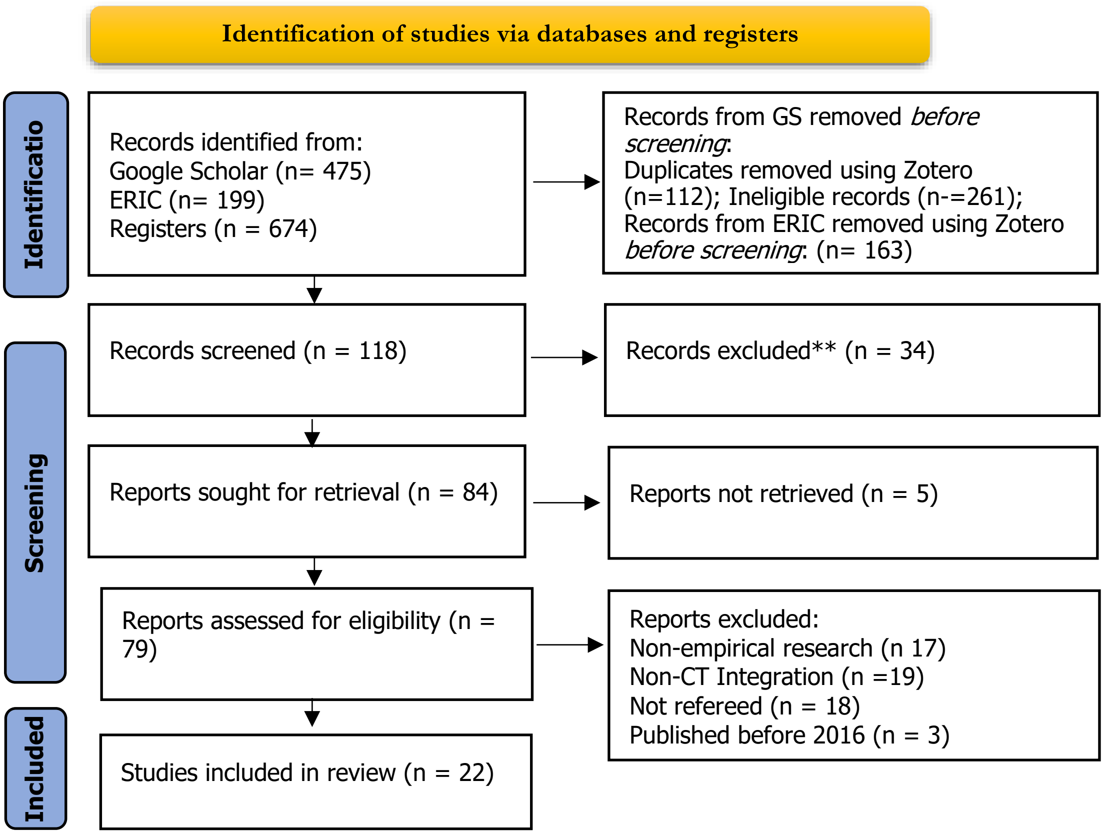
On the next day I conducted another search in ERIC, using Boolean logic "computational thinking" "EFL" AND "English language learning" search terms, "peer reviewed only" category, and "since 2016" for publication date, yielding 199 initial records. I screened them using the same procedure for screening the records obtained from GS. The 36 records obtained were combined with the 82 records obtained from GS in Mendeley. After deleting 34 duplicates, I retrieved the 84 records but found five of them irretrievable. Then I rescreened the 79 documents individually by reading their titles and abstracts, followed by a detailed evaluation to decide their eligibility according to the inclusion and exclusion criteria. Based on the rescreening results, I decided to discard 51 records; retaining 22 records to analyze in the study (see Figure 2).

Data Analysis

To capture both thematic clarity and conceptual depth, this review adopted a hybrid analytical framework combining thematic analysis (TA) and the constant comparative method (CCM). This approach enabled the identification of recurring pedagogical patterns while allowing for iterative refinement and cross-contextual comparison. Sun et al. (2025) accentuated that the integration of CCM enhanced the interpretive rigor of TA by enabling adductive reasoning and theory-informed synthesis.

Figure 2

PRISMA 2020 Flow Diagram of Study Selection



Thematic Analysis

In this study, I used Thematic Analysis (TA) to generate initial codes and organize them into candidate themes. The process covers the six-phase protocol proposed by Braun and Clarke (2021) described in Table 4.

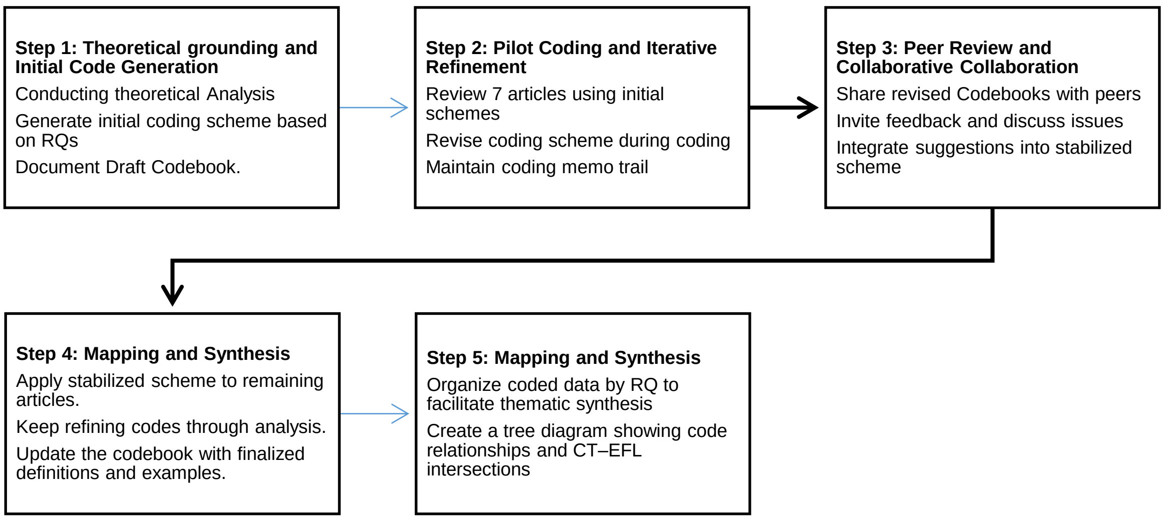
Table 4.
Thematic Analysis Phases

Phase No.	Phase Name	EFL-Focused Activity	Output
1	Familiarization	Reading full texts, noting CT instances	Initial memos
2	Initial Coding	Labeling passages related to abstraction, pattern recognition, etc.	Codebook draft
3	Theme Generation	Grouping codes based on the research questions, e.g., educational contexts, CT learning modalities	Candidate themes
4	Review & Refinement	Collapsing overlapping themes across STEM vs. humanities contexts, pedagogical approaches, EFL Focuses, etc.	Refined theme list
5	Definition & Naming of themes	Crafting the names of themes	Thematic definitions table
6	Translation & Visualization	Designing infographics and bilingual summary tables	Visual artifacts for findings

Coding for Thematic Analysis

To systematically analyze literature on CT integration into EFL education, I developed and refined a coding scheme aligned with five research questions (RQs), grounded in theory and enriched through iterative peer engagement. Figure 3 illustrates the procedure.

Figure 3.
RQ-driven Coding Scheme Procedure



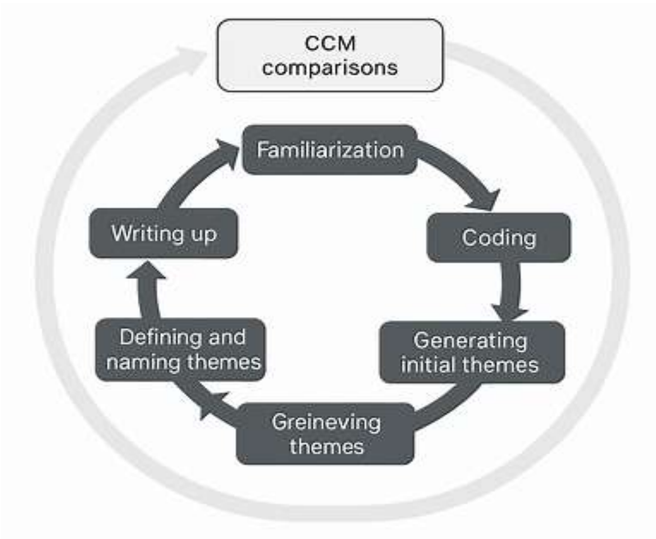
Constant Comparative Method (CCM).

I employed CCM to compare codes and themes across studies, CT modalities, and regional contexts. This iterative process supported (1) refinement of categories through cross-case analysis, (2) detection of conceptual shifts in CT-EFL pedagogy, and (3) construction of comparative models and summary tables. In this study, I applied CCM in the following steps:

1. Cross-study comparison of theme frequencies and contextual nuances.
2. Iterative category refinement: merging, splitting, or re-naming themes based on new cases.
3. Construction of comparative matrices (e.g., CT modality vs. educational level).

Figure 4 illustrates the process of the hybrid analysis. The inner loop showing the six TA phases in sequence. The outer loop illustrating CCM comparisons feeding back into TA phase refinement.

Figure 4.
Hybrid TA-CCM Workflow

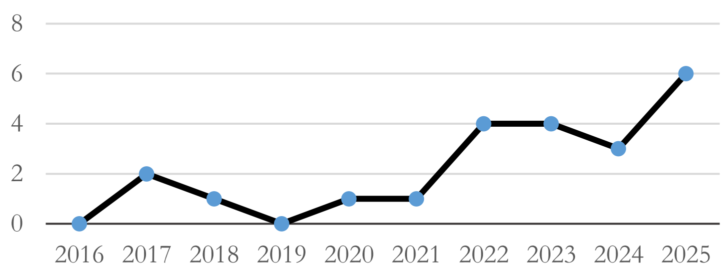


RESULTS AND DISCUSSION

Overview of the Included Studies

Twenty-two studies met the inclusion criteria, spanning China (4), Hong Kong (2), Taiwan (7), Indonesia (7), Turkey (1), and Thailand (1). From 2016 to 2025, there has been a clear upward trend in CT integration into EFL learning (Figure 5), reflecting growing academic interest—particularly in Asian contexts such as China, Taiwan, and Indonesia.

Figure 5.
Included Studies by Publication Year



CT-EFL learning modalities employed were categorized as unplugged (13 studies), plugged (e.g., Scratch, educational robots, Assemblr EDU QR-code texts; 8 studies), and hybrid (1 study).

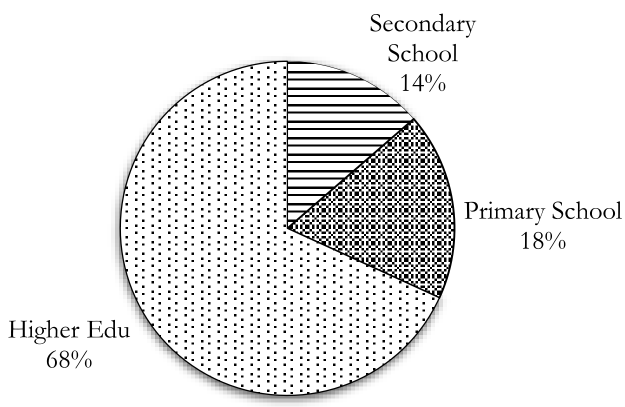
EFL focus areas included academic writing (6), creative writing (5), reading comprehension (4), dialogue learning (2), vocabulary and sentence practice (2), grammar application (2), and peer-feedback integration (1). Most studies targeted university students (68%), followed by primary (18%) and senior high school students (14%). EFL focus areas encompassed academic writing (6), creative writing (story, poetry, or scriptwriting, 5 studies), reading comprehension (4), dialogue learning (2), vocabulary and sentence practice (2), grammar application (2), and peer-feedback integration (1). In terms of educational levels, a majority of the research involved university students (68%), followed by primary school students (18%), senior high school students (14%), respectively.

Educational Contexts

As shown in Figure 6, higher education (HE) dominates CT-EFL integration (68%), positioning it as a hub for pedagogical innovation. Primary school (PS) accounts for 18%, likely reflecting global trends in early CT exposure. Secondary school (SS) trails at 14%, suggesting structural or curricular barriers.

Figure 6.

Educational Contexts of CT Integration into EFL Learning



In HE, CT is often treated as an advanced pedagogical tool, supported by instructor autonomy and students' readiness for abstract reasoning. For example, Suhendra et al. (2024) reported improved comprehension and problem-solving among engineering students using CT-infused reading modules—though the intervention remained elective. Similarly, Suciati et al. (2023) demonstrated the effectiveness of peer feedback in CT-integrated writing courses, yet the study was a pilot. These patterns echo Parekh & Sadaria (2024), who note that CT integration in humanities remains fragmented and experimental. To move beyond pilot efforts, CT should be embedded into core EFL curricula, supported by scalable models, institutional backing, and faculty development.

In PS contexts, unplugged CT strategies—such as storytelling, pattern recognition, and logic games—align well with young learners' developmental stages. Hsu & Liang (2021) found that both plugged (robot games) and unplugged (board games) approaches improved vocabulary and sentence proficiency, with lower anxiety observed in plugged settings. These findings align with Giannakoulas & Xinogalos (2024). who highlight the benefits of narrative-based and pattern-driven educational games. However, successful integration requires empowered teachers, sufficient instructional time, project-based learning, and cross-subject CT modules. Among these, teacher competence is paramount; Liu et al. (2024) identify inadequate CT experience as a key barrier.

Secondary school students are cognitively prepared for CT integration but require intuitive, engaging, and well-supported instruction. Dewi et al. (2025) showed that culturally relevant digital reading modules enhanced CT and problem solving, despite occasional technical challenges. Weng et al. (2018) emphasized that pedagogical design—aligned with learners' prior knowledge—is critical. Still, systemic barriers persist: standardized testing, rigid syllabi, and limited teacher training often constrain innovation. Li et al. (2024) and Aureza & Emaliana (2024) note that CT integration remains rare unless explicitly mandated. To address this, scalable, context-sensitive CT-EFL modules and targeted teacher empowerment are essential.

Pedagogical Approaches in CT Integration

CT integration in EFL learning typically follows three pedagogical modalities: plugged, unplugged, and hybrid. Plugged approaches involve educational technologies such as digital games, coding platforms, educational robots, and interactive simulations. Unplugged approaches rely on physical or conceptual tasks—board games, puzzles, flowcharts, and paper-based exercises—that foster critical and systematic thinking without digital tools. Hybrid approaches combine both, blending tangible and digital strategies to scaffold CT development. Table 5 summarizes the distribution of these approaches across educational levels. Unplugged methods dominate in higher education (HE), while plugged approaches are most common in primary school (PS). Only one study employed a hybrid model, implemented in PS. No hybrid approaches were found in HE, and no unplugged approaches were reported in PS. Studies in secondary school (SS) employed one plugged and two unplugged approaches.

Table 5.

Pedagogical Approaches in CT-EFL Learning Integration

CT Approach	Primary School (PS)	Secondary School (SS)	Higher Education (HE)	Total
Plugged	4	1	1	6
Unplugged		2	13	15
Hybrid	1	0	0	1

The strong prevalence of unplugged approaches in HE (13 out of 15 studies) reflects a pedagogical orientation toward CT as a cognitive and instructional strategy rather than a technological tool. This trend is likely driven by two factors. First, an emphasis on metacognition and disciplinary integration, particularly in writing-focused courses (e.g., Hsu et al., 2022; Paster, 2025; Wu et al., 2024). Second, faculty-led innovation grounded in interpretive or constructivist paradigms, which prioritize meaning-making, reflection, and learner agency (e.g., Weng et al., 2018).

Unplugged CT-EFL approaches align with interpretivist pedagogy in three key ways. First, they emphasize conceptual reasoning, pattern recognition, and decomposition through discussion and analogical thinking. Second, they foster learner agency via tasks like algorithmic storytelling, logic-based grammar exercises, and CT-infused reading strategies. Third, they allow flexible adaptation to disciplinary contexts, such as writing and literature analysis. For example, Bayraktar and Gulbahar (2022) embedded CT skills—abstraction, decomposition, pattern recognition, and algorithm design—into poetry writing through project work and peer reflection. Murti et al. (2022) guided students through decomposition of writing tasks, abstraction via lexical choices, algorithmic paragraph structuring, and peer-based evaluation. These studies illustrate how unplugged CT cultivates thinking habits deeply embedded in interpretation, analysis, and expression—making it a natural fit for HE environments.

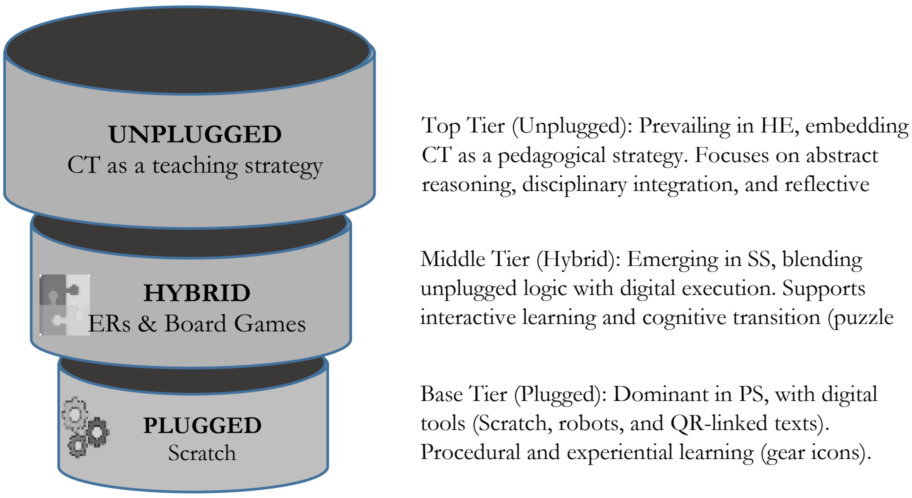
Plugged approaches were concentrated in PS, leveraging tools such as Scratch (Parsazadeh et al., 2020; Weng et al. 2018; Weng & Wong, 2017), educational robots (Hsu et al., 2022), and QR-linked 3D texts via Assemblr Edu (Sagita et al., 2025). These tools offer age-appropriate engagement through visual programming and robotics, serving as motivational anchors for CT concepts. For instance, Weng and Wong (2017) selected Scratch for learners aged 10–11 who had prior exposure to the platform. Parsazadeh et al.'s (2020) found that ninth-grade students experienced reduced anxiety and increased engagement through Scratch-based activities. Plugged approaches thus introduce young learners to CT through interactive, tangible tools that scaffold abstract thinking in accessible ways.

Hybrid implementation was rare, with only one study (Hsu & Liang, 2021) combining educational robots (ERs) and board games in PS. This model represents a transitional pedagogy that blends experiential and conceptual learning—suggesting potential for future innovation in blended CT instruction.

Plugged approaches in SS and HE were selectively applied. Dewi et al. (2025) used digital reading modules to enhance CT and multimodal literacy in SS, while Sagita et al. (2025) employed QR-linked 3D models in HE. These cases reflect niche innovations rather than systemic integration, indicating room for broader adoption.

Overall, the findings reveal a developmental continuum in CT-EFL integration: CT as tool dominates in PS, CT as blended pedagogy emerges in SS, CT as cognitive strategy prevails in HE. The underexplored hybrid approach represents a promising area for future research. Based on these findings, the author proposes a CT-EFL Learning Integration Developmental Continuum Model (Figure 7), mapping pedagogical progression across learner maturity levels.

Figure 7.
CT-EFL Learning Integration Developmental Continuum Conceptual Model



EFL focuses and Learning Outcomes

Table 6 reveals that academic writing was the most frequently addressed EFL focus, followed by creative writing, reading, vocabulary, grammar, dialogue, and sentence structure. In all quasi-experimental studies, these EFL domains served as dependent variables, with CT skills as independent variables. The overarching finding: CT integration significantly and positively impacted students' learning outcomes across all foci.

Table 6.
EFL Focuses and Learning Outcomes

EFL Focuses	No. of Studies	Students' Learning Outcomes
Academic Writing	7	Higher performance vs. control; structured thinking
Creative Writing	4	Improved vocab, speaking, motivation, cooperation, time management
Reading	4	Better reading skills, confidence, CT skills
Vocabulary	2	Vocabulary gains
Grammar	2	Significant grammar improvement
Dialogue Learning	2	Increased motivation and interest
Sentence Structure	1	Enhanced structural skills

The dominance of academic writing is attributable to three key factors. First, tertiary context prevalence: Most reviewed studies were conducted in higher education, where writing tasks are cognitively demanding and central to academic success. Second, natural alignment with CT components: Writing tasks inherently involve decomposition (structuring arguments), abstraction (summarizing ideas), and algorithmic thinking (organizing paragraphs logically). Third, assessment feasibility: Writing yields tangible artifacts—essays, drafts, revisions—that are amenable to rubric-based evaluation, textual analysis, and pre-post comparisons, making CT's impact more measurable. Creative writing and reading followed in frequency. Creative writing benefits from CT strategies such as pattern recognition, logical sequencing, and abstraction, which support genre awareness and narrative construction. Reading, while cognitively rich, was less emphasized—likely due to assessment complexity and limited teacher familiarity with CT-reading integration. Nonetheless, reading tasks benefit from CT strategies like inferencing, decomposition, and evaluation, especially in academic contexts.

CT Skills Distribution by EFL Focus

To support educators in designing adaptive scaffolding for CT-EFL integration, this review maps dominant CT skills within each EFL focus to their corresponding cognitive load levels. Cognitive load refers to the mental effort required to process information. According to Paas et al. (2003, as cited in Liu et al., 2024a), it is a multifaceted construct representing the burden on learners' cognitive systems during task performance. Cognitive load theory offers significant perspectives and design principles for instruction and instructional materials. For instance, instructional designers should avoid excessive cognitive load, as it can impede knowledge construction and understanding (Liu et al., 2024).

CT skills were categorized into three cognitive load levels: high, medium, and low. High load CT skills include those requiring recursive reasoning and schema construction, e.g., abstraction, algorithm design, debugging, evaluation (Mohammed & Amhimid, 2025; Shin et al., 2025). Moderate load CT skills include decomposition and pattern recognition (Krell et al., 2022). They require sustained attention but are manageable with proper instructional design. Low load CT skills include procedural CT tasks like sequencing and basic data analysis (Bakar et al., 2019).

Table 7 maps CT skills distribution by EFL focus and cognitive load with a color gradient representing cognitive load levels—from high (red) to low moderate (green). It shows that CT-infused writing tasks—both academic and creative—consistently impose high cognitive load, due to recursive abstraction, algorithmic structuring, and evaluative reasoning. Shin et al. (2025) found that tasks involving debugging and algorithm design significantly increased cognitive load in collaborative programming, a pattern echoed in EFL writing contexts. Learners must construct coherent arguments, navigate genre conventions, and engage in iterative revision—demanding sustained cognitive effort.

Reading tasks involve two high-load skills (evaluation and abstraction) and two moderate-load skills (decomposition and pattern recognition), resulting in a moderate–high cognitive load. With appropriate scaffolding—such as segmentation and visual aids—these tasks remain manageable (Krell et al., 2022).

Grammar and dialogue learning typically involve moderate cognitive load, benefiting from pattern-based reasoning and procedural logic. Angeli & Giannakos (2020, as cited in Shin et al., 2025) emphasized that CT integration in non-engineering domains thrives when instructional design balances cognitive demand through segmentation and visual support.

Vocabulary instruction, by contrast, carries low to moderate cognitive load, making it ideal for early-stage learners. Foundational CT tasks like sequencing and basic data analysis (Bakar et al., 2019; Ismail et al., 2010) are cognitively accessible and support lexical expansion as a procedural, layered process.

Table 7.
CT Skills Distribution by EFL Focus and Cognitive Load

EFL Focus	Dominant CT Skills	Pedagogical Implications	Cognitive Load
Academic Writing	Generalization, Decomposition, Error detection and correction (debugging), Abstraction, Algorithm Design, Evaluation.	CT scaffolds idea generation, argument development, paragraph structuring, coherence building, and peer-review cycles.	High
Creative Writing	Abstraction, Logical Reasoning, Pattern Recognition, debugging, Algorithm Design, Decomposition	CT enables information filtering, genre analysis, multimodal composition, and structural analysis.	High
Reading	Evaluation, Decomposition, Pattern Recognition, Abstraction	CT enhances critical reading, information filtering, and structural analysis	Moderate-high
Grammar	Data Analysis, Pattern Recognition, Abstraction, Parallelization	CT makes grammar instruction as inquiry-driven, pattern-based, and cognitively engaging	Moderate
Dialogue Learning	Flow Control, Logic, User Interactivity, Data Representation, Synchronization	Scratch-based dialogue fosters procedural thinking and multimodal language use	Moderate
Vocabulary	Data Analysis, Abstraction, Decomposition, Pattern Recognition	Lexical expansion is framed as a layered, procedural, and associative CT process	Low-Moderate

The Challenges and Opportunities EFL Educators Face in CT–EFL Integration

Despite growing enthusiasm for embedding CT in EFL contexts, educators' voices remain underrepresented. Of the 22 studies reviewed, only five directly involved classroom teachers (see Table 8), revealing a critical gap in understanding the lived challenges and enabling conditions for CT–EFL integration. Synthesizing these cases surfaces four interrelated barriers—knowledge gaps, time constraints, inadequate professional development (PD), and nascent teacher beliefs—while pointing to strategic opportunities for sustainable implementation.

While many EFL educators possess general digital literacy, few demonstrate the pedagogical fluency needed to translate CT principles into language learning activities. For instance, the teacher in Weng and Wong (2017) and Weng et al. (2018) had three years of Scratch experience but no exposure to CT-infused language lesson design. This disconnect highlights the need for targeted curricula that explicitly map CT constructs—such as decomposition and pattern recognition—onto communicative tasks, enabling educators to align language objectives with computational frameworks.

Moreover, current PD models have not adequately prepared teachers for CT–EFL integration. Dijaya et al. (2017) identified time constraints and competing responsibilities as major inhibitors. Conventional PD often emphasizes technical proficiency ("how to code") over pedagogical application. In Indonesian higher education, (Qamariah, 2025) found that most CT-relevant PD is self-initiated, with instructors piecing together webinars and workshops in the absence of institutional support—resulting in uneven uptake and limited classroom transferability. Parsazadeh et al. (2020) similarly observed that teachers leave such sessions with software skills but lack strategies to foster student reflection, collaboration, or language development through CT.

Table 8.
The Challenges and Opportunities Educators Face in CT-EFL Integration

Studies	Challenges	Opportunities
Weng & Wong (2017), Weng et al. (2018)	Teacher experienced in Scratch but lacked guidance on CT–EFL integration practices and field-specific PD.	Build on existing digital literacies to co-design CT–EFL modules; develop targeted PD that bridges Scratch and EFL learning.
Dijaya et al. (2017)	Instructors feel underprepared in CT pedagogies and report insufficient time to plan and deliver CT-infused lessons.	Leverage collaborative lesson-planning sessions; embed CT tasks within existing syllabus structures to minimize extra workload.
Bayraktar & Gulbahar (2022)	Pre-service teachers initially unaware of CT skills, requiring foundational training before classroom application.	Use iterative, scaffolded workshops during teacher education to foster CT fluency; encourage peer-led demonstration lessons.
Parsazadeh et al. (2020)	Lack of knowledge and confidence in designing CT activities for EFL contexts.	Pair language instructors with CT-specialist mentors; create micro-credentialing pathways in CT–EFL integration.

A more effective PD model would integrate mini-lectures on CT theory with co-planning labs, where educators collaboratively design and implement CT–EFL lessons, followed by iterative coaching cycles. Liu et al. (2024a), in the STEM context, emphasized that sustained, practice-oriented PD is the most viable pathway for CT integration. Bayraktar and Gulbahar (2022) demonstrated that pre-service teachers, initially unfamiliar with CT, can become confident advocates within a single semester of contextualized, hands-on training. This rapid transformation underscores the power of experiential workshops, peer modeling, and reflective debriefs. To scale such belief shifts, CT modules must be embedded throughout teacher education programs—not relegated to standalone electives.

This review highlights the evolving landscape of CT–EFL integration, revealing both conceptual advances and persistent implementation challenges. While studies increasingly explore CT-infused pedagogies, few center the lived experiences of EFL educators. The five teacher-focused studies expose four interrelated barriers—knowledge gaps, time constraints, inadequate professional development, and nascent teacher beliefs—yet also illuminate strategic opportunities for sustainable integration. Effective models build on existing digital literacies, embed CT tasks within syllabus structures, and offer practice-oriented PD that fosters pedagogical fluency. Pre-service and in-service teachers alike benefit from scaffolded training, peer-led demonstrations, and iterative design cycles. Ultimately, bridging CT and EFL requires not only curricular innovation but also systemic support for teacher learning, belief transformation, and collaborative resource development.

CONCLUSION

Integrating CT into EFL instruction consistently enhances student learning outcomes across writing, creative tasks, reading, vocabulary, grammar, dialogue, and sentence structure. High-load CT components—such as abstraction, algorithm design, and debugging—align naturally with writing tasks but require careful scaffolding, while moderate- and low-load skills support reading, grammar, and vocabulary development. Dynamic visualization (heat map) enrich my understanding of CT–EFL mappings and evolving research trends. However, only five of 22 studies engaged teacher perspectives, uncovering critical barriers in knowledge, time, professional development, and belief. Addressing these gaps is essential for sustainable, classroom-ready CT–EFL models that center both learner gains and educator experiences.

The results and discussion indicating that CT-EFL learning integration is both interesting and expansive reveal that good work had been started, but there is a lot more to do. Thus, I suggest policymakers, researchers, and practitioners consider the following recommendations concerning CT-EFL integration. Recommendations for policy makers: (1) Develop national frameworks that integrate CT principles into EFL curricula, emphasizing decomposition, pattern recognition, and abstraction alongside language standards; (2) Fund sustained, context-specific professional development programs blending CT theory with co-planning labs and coaching cycles; (3) Support micro-credentialing initiatives that formally recognize teacher proficiency in CT–EFL integration; (4) Encourage collaboration between universities, schools, and technology providers to co-design scalable CT–EFL modules and resources. Recommendations for English educators: (1) Embed CT tasks within existing lesson plans (e.g., flowchart story mapping in reading comprehension) to minimize additional planning time; (2) Leverage low-load CT activities (sequencing, basic data analysis) early in courses, gradually introducing higher-load components with worked examples and peer protocols; (3) Participate in or establish professional learning communities to co-design CT–EFL units, share rubrics, and conduct peer demonstrations. Recommendations for further research: (1) Conduct longitudinal studies tracking teacher adoption, belief transformation, and classroom sustainability of CT–EFL integration; (4) Expand qualitative inquiry into instructor experiences, exploring contextual enablers and inhibitors through interviews, focus groups, and reflective logs; (5) Investigate CT–EFL integration in diverse educational settings (e.g., K–12, corporate training) and across proficiency levels to enhance generalizability; (4) Evaluate the efficacy of specific scaffolding techniques (worked examples, peer protocols, micro-credentials) on both learner outcomes and teacher confidence.

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