

## Systematic Literature Review: Computational Thinking Through Unplugged Activities Based On Spatial Reasoning Maps

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**Abstract.** Computational thinking (CT) has been recognized as a fundamental 21st-century literacy, yet its integration into the elementary curriculum remains constrained by limited technological resources. This systematic literature review synthesizes research evidence on map-based unplugged activities for fostering CT skills, proposing a novel framework positioning spatial reasoning as the cognitive catalyst. Following PRISMA guidelines, this review examined peer-reviewed studies from multiple international databases, applying predefined inclusion criteria aligned with elementary education contexts. Findings demonstrate strong alignment between cartographic practices, spatial reasoning, and CT components, particularly through activities such as map-making and grid navigation. However, challenges persist in transferring unplugged CT skills into digital contexts. To address this gap, the Up-SpCT Pedagogical Model is introduced as a structured developmental pathway bridging spatially grounded unplugged experiences and digital CT engagement. This review highlights that map-based unplugged activities can be effectively integrated into elementary classrooms to build computational thinking foundations. The findings provide practical guidance for teachers to design spatially grounded unplugged lessons and inform curriculum developers on integrating CT as a transversal competency in primary education..

**Keywords:** Computational Thinking, Unplugged Activities, Map-Based Learning, Spatial Reasoning, Primary Education

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### INTRODUCTION

The rapid digital transformation across societal, economic, and educational sectors has amplified the urgency of equipping young learners with the cognitive skills required to navigate an increasingly computational world. Among these competencies, Computational Thinking (CT) has emerged as a core analytical literacy for the 21st century. Initially conceptualized by Wing (2006), CT extends beyond programming to encompass a problem-solving framework involving decomposition, pattern recognition, abstraction, and algorithmic thinking. These competencies enable learners to formulate and analyze problems in ways that can be executed effectively by humans or machines.

In Indonesia, the Ministry of Education's Kurikulum Merdeka emphasizes the integration of higher-order thinking skills and digital fluency across subjects, including in primary education. CT is positioned as a transversal competency that supports problem solving and inquiry-based learning. However, CT implementation at the elementary level remains challenged by disparities in access to digital infrastructure, uneven teacher readiness, and limited availability of developmentally appropriate CT learning models. While digital platforms and coding tools are increasingly promoted, many schools—particularly in rural or resource-limited regions—struggle to sustain technology-dependent CT programs.

Unplugged pedagogy offers a promising pathway to address these barriers. Rooted in the CS Unplugged movement, unplugged learning introduces CT concepts through hands-on, game-based, and contextually meaningful activities without relying on electronic devices. This approach reduces cognitive load for novice learners, avoids overreliance on screens, and builds conceptual readiness prior to engaging in digital CT activities. Within this context, map-based learning emerges as an accessible and highly relevant modality for Indonesian primary education, particularly within the Ilmu Pengetahuan Alam dan Sosial (IPAS) curriculum, which integrates scientific and social inquiry. Despite growing attention to CT and spatial reasoning, there remains a notable research gap regarding how map-based unplugged approaches can systematically develop and transfer CT skills from conceptual to digital contexts. This gap underscores the need for a structured pedagogical framework that bridges spatial reasoning and CT within primary education.

Map-based learning provides authentic spatial problem-solving experiences that naturally align with CT. When students create, interpret, or navigate maps, they develop spatial reasoning—an essential cognitive skill underpinning CT and STEM disciplines. Spatial reasoning encompasses mental rotation, spatial visualization, symbolic interpretation, and spatial sequencing. These processes closely parallel CT competencies, suggesting that spatial reasoning may act as a cognitive bridge that strengthens CT development in unplugged contexts. Despite the theoretical alignment, there is a lack of consolidated evidence and structured pedagogical models guiding how map-based unplugged learning can systematically advance CT skills and transfer to digital contexts.

This review addresses these gaps by synthesizing empirical studies on map-based unplugged interventions for CT development in primary education and by proposing the Up-SpCT Pedagogical Model—a developmental progression that integrates spatial reasoning as a cognitive foundation for CT. The review aims to: (1) examine how map-based unplugged activities foster CT skills, (2) evaluate the effectiveness of such interventions, and (3) propose a hybrid model that supports the transfer of CT from unplugged to digital learning environments.

## **METHODOLOGY**

This study employed a Systematic Literature Review (SLR) approach to synthesize empirical evidence on the use of map-based unplugged activities to foster CT skills in primary education. The SLR followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological rigor, transparency, and replicability. The

review process consisted of five phases: defining the research questions, identifying relevant studies, screening and quality assessment, data extraction, and synthesis.

### Search Strategy and Eligibility Criteria

A comprehensive search was conducted across four major scholarly databases—Scopus, Web of Science, ERIC, and Google Scholar. The search covered publications from 2006, following the year Wing introduced the CT concept, to 2024. Keywords and Boolean operators used included: “computational thinking” AND “unplugged activities”, “map-based learning”, “spatial reasoning”, “primary school”, “elementary education”, and their synonyms.

To be included, studies were required to meet the following criteria:

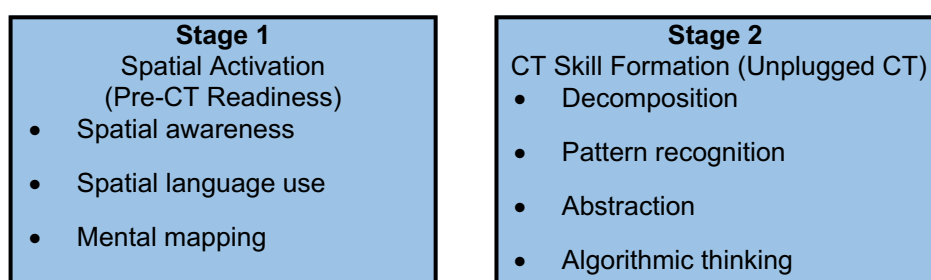
- (1) peer-reviewed journal or conference publications;
- (2) conducted in primary/elementary school contexts (ages 6–12);
- (3) reported CT outcomes;
- (4) involved map-based, spatial, or navigation-focused unplugged activities;
- (5) written in English or Bahasa Indonesia.

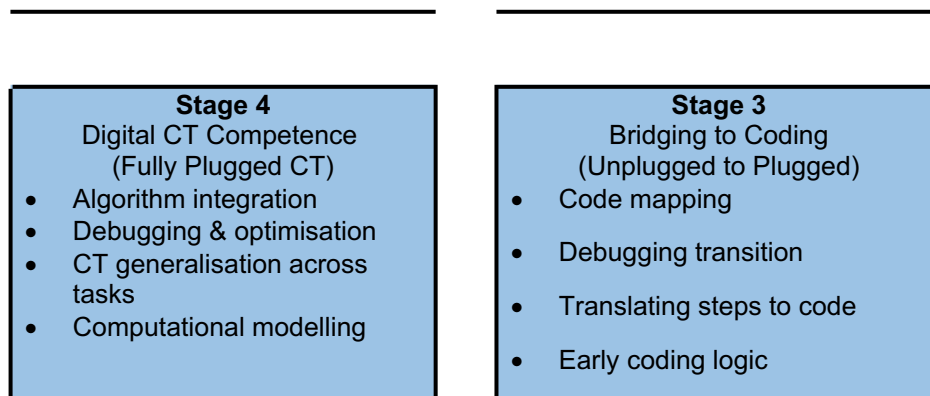
Studies focusing solely on secondary or tertiary education, theoretical papers without empirical data, or studies lacking methodological clarity were excluded.

### Study Selection and PRISMA Flow

The database search yielded 312 records. After removing duplicates, 247 abstracts were screened for relevance. A total of 74 full-text articles were reviewed in detail, and 49 met all inclusion criteria for final synthesis. Quality appraisal considered methodological rigor, sample adequacy, clarity of intervention design, and the validity of CT assessment instruments. The PRISMA-based selection procedure ensured that only studies with credible and traceable evidence were included.

### Ability to Digital CTD





**Figure 1.** PRISMA Flowchart of the Study Selection Process

### Data Extraction and Synthesis

Data from the selected studies were extracted using a structured matrix capturing: author(s), year, country, participants, intervention type, CT components addressed, instruments used, and key findings. A thematic synthesis approach was used to integrate results across studies, organised around the four CT pillars—decomposition, pattern recognition, abstraction, and algorithmic thinking—and the role of spatial reasoning. To strengthen reliability, cross-comparison was applied to identify convergent and divergent findings across studies.

### RESULTS AND DISCUSSION

These findings indicate that map-based unplugged activities consistently foster CT skills among primary learners, with strong alignment observed between spatial reasoning processes and CT components. Activities such as map-making, grid navigation, treasure-hunt games, and classroom mapping were shown to strengthen decomposition, pattern recognition, abstraction, and algorithmic thinking simultaneously. These activities engage learners in spatial visualisation, directional reasoning, and symbolic interpretation, reinforcing the cognitive foundations needed for CT. A summary of key studies supporting these findings is presented in Table 1.

**Table 1.** Summary of Key Studies Linking Unplugged Map-Based Activities and Computational Thinking (CT) Outcomes in Elementary Education

Researcher & Year	Context & Components	CT	Key Findings
Chen, Jong, & Chai (2023)	Meta-analysis (49 studies) – all CT pillars		Large effect size (Hedges' $g = 1.028$ , $p < .001$ ). Unplugged pedagogy is highly effective in improving CT among K–12 students.
Brackmann et al. (2017)	Elementary schools in Argentina – all CT pillars		Unplugged activities significantly enhanced CT even without technology; effective in low-resource school settings.
del Olmo-Muñoz et al. (2020)	Lower elementary unplugged navigation, symbols, grid-based tasks		Unplugged activities effectively introduce CT concepts to young learners in a practical and enjoyable way.
Korkmaz et al. (2017)	CT Scale instrument validation		CT Scale (CTS) is valid and reliable for measuring students' CT skills.
Wang, Chen, & Chen (2023)	AR board game "Coding Ocean" – algorithms & decomposition		AR group outperformed non-AR; improved CT and early programming understanding.
Dafia et al. (2024)	Indonesian elementary students, map media in IPAS (implicit CT)		Map-based media increased engagement and conceptual understanding; strong potential for CT integration in IPAS.
Syamsiah (2024)	Unplugged Bebras – all CT pillars		Significant improvement in CT following unplugged coding intervention.

Researcher & Year	Context & Components	CT	Key Findings
Erümit (2024)	Hybrid unplugged plugged – CT focus	→ transfer	Combination of unplugged and plugged activities more effective than either alone; improved CT transfer.
Akiba (2022)	Treasure Hunt” activity – all CT pillars		Unplugged is suitable for early CT development, but a bridge to digital activities is necessary for progression.
Maharani (2023)	Bibliometric study on CT in elementary schools		Research on CT is increasing, but spatial-based unplugged CT remains an underexplored area.

### A Development of CT through Map-Based Tasks

Decomposition was strengthened as learners broke down navigation tasks into sequential steps. Pattern recognition emerged when students identified recurring spatial symbols, routes, and map features. Abstraction was evident when simplifying real-world environments into maps by filtering essential information. Algorithmic thinking was developed when learners generated step-by-step instructions to reach a destination.

### Effectiveness of Unplugged Interventions

Multiple studies reported positive learning outcomes and increased engagement, particularly when map-based tasks were implemented through collaborative and game-based learning. A meta-analysis (Chen, Jong, & Chai, 2023) synthesising 49 studies in K-12 contexts found a large effect size (Hedges’  $g = 1.028$ ,  $p < 0.001$ ) for unplugged CT interventions, demonstrating their strong potential even in low-tech educational environments. Studies in Indonesia (Dafia et al., 2024; Syamsiah, 2024) showed improved participation and conceptual understanding in IPAS lessons when map media and unplugged CT activities were integrated. Comparative analysis across studies from diverse cultural contexts revealed differences in pedagogical emphasis. For instance, Asian studies (e.g., Indonesia, China) tend to integrate map-based CT within inquiry and environmental mapping lessons, while Western contexts (e.g., Spain, Argentina) emphasize game-based or symbolic navigation approaches. These variations suggest that socio-cultural and curricular orientations influence how spatial reasoning and CT are contextualized, highlighting the importance of culturally responsive unplugged designs.

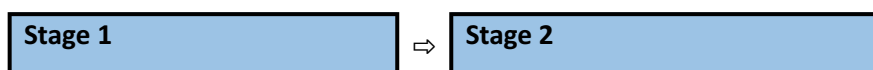


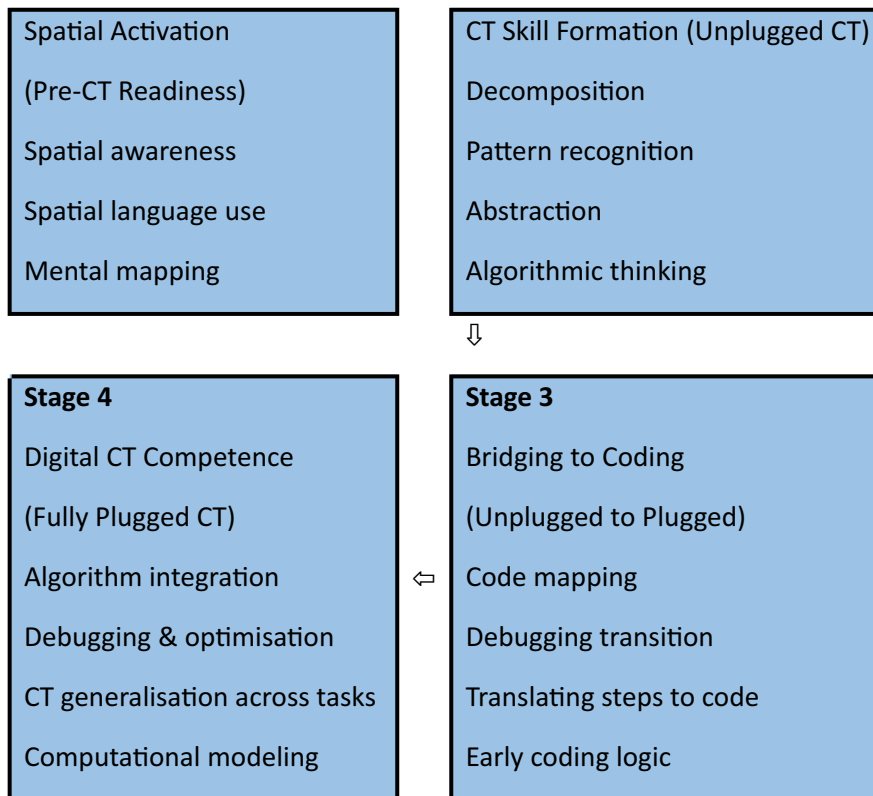
### Gap: Transferability to Digital CT

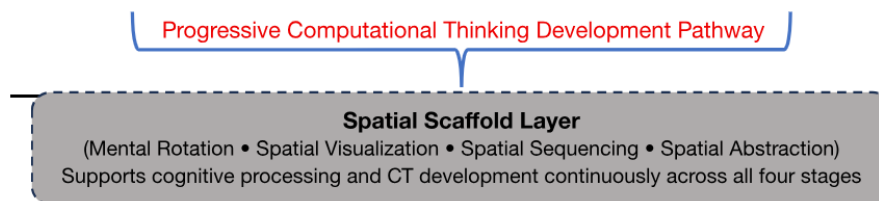
Despite strong evidence for CT gains in unplugged contexts, a key challenge identified across studies is the transfer of CT skills from unplugged to digital (plugged) settings. Only approximately 15% of reviewed studies examined this transition explicitly. Among these, positive transfer occurred when learners first mastered unplugged spatial-based CT tasks before transitioning to scaffolded digital coding activities. Without explicit bridging, transfer tended to be minimal, suggesting that unplugged CT is foundational but insufficient alone without structured digital follow-up.

### The Up-SpCT Pedagogical Model

The Up-SpCT Pedagogical Model To address the gap in transferring CT from unplugged to digital contexts, this review proposes the Up-SpCT Pedagogical Model. The model is a four-stage developmental pathway designed to strengthen CT through spatial reasoning, ensuring conceptual-to-digital transferability. A visual representation of the Up-SpCT Pedagogical Model can be seen in Figure 2 below.







**Figure 2.** The Up-SpCT Pedagogical Model

As illustrated in Figure 2, the Up-SpCT Pedagogical Model is executed through a developmental loop, where the Spatial Scaffold Layer supports the entire learning journey. The model follows a clear progression across four distinct phases to facilitate the transfer of CT skills. The four stages are:

**Stage 1: Spatial Familiarisation (Unplugged – Concrete)**

Learners engage in hands-on spatial tasks such as classroom mapping, treasure hunts, and directional games. The focus is on building foundational spatial skills including visualisation, mental rotation, and symbol interpretation.

**Stage 2: Spatial-CT Integration (Unplugged – Semi-Abstract)**

Map-based tasks are intentionally designed to incorporate CT elements. Learners decompose navigation tasks into sub-steps, identify spatial patterns, abstract key map features, and formulate directional algorithms. Spatial reasoning and CT are explicitly linked.

**Stage 3: CT Abstraction and Representation (Unplugged-to-Plugged Transition)**

Learners convert spatial-based CT solutions into structured representations such as flowcharts, pseudocode, or arrow-based command sequences. This stage bridges physical tasks with symbolic CT representations used in computing.

**Stage 4: Digital CT Application (Plugged – Abstract)**

Learners implement their unplugged algorithms in digital coding tools (e.g., Scratch, Blockly, Code.org). Spatial-based unplugged logic is translated into block-based or text-based code. This stage strengthens transfer and prepares learners for more advanced CT tasks.

This progression aligns with cognitive development and reduces cognitive load by ensuring that students build conceptual mastery before engaging with digital CT environments. The model supports teachers in planning hybrid CT instruction aligned with Kurikulum Merdeka and IPAS inquiry-based learning.

**CONCLUSION**

This review concludes that map-based unplugged activities are effective for developing CT skills in primary education. Their strength lies in leveraging spatial reasoning as a cognitive catalyst that naturally aligns with the four CT pillars. Such activities provide accessible, low-resource, and engaging learning experiences suitable for diverse educational contexts, particularly in Indonesia.

However, unplugged activities alone are insufficient to guarantee transfer of CT to digital coding environments. The Up-SpCT Pedagogical Model addresses this by guiding educators through a four-stage progression that builds from spatial experiences to digital CT application.

Recommendations include: (1) Teachers should embed CT explicitly within IPAS and mathematics lessons through map-based inquiry tasks; (2) Curriculum developers should adopt an unplugged-first hybrid CT model to support equitable access and gradual transition to digital CT; (3) Future research should examine long-term effects of spatial–CT integration and validate assessment instruments for unplugged CT performance.

Practical Implications: Teachers can begin by integrating map-making, treasure-hunt navigation, and classroom mapping tasks that embed CT pillars such as decomposition and pattern recognition. Lesson sequences can follow the Up-SpCT progression, ensuring students first build spatial familiarity before transitioning to algorithmic and coding representations. Such stepwise integration supports effective CT transfer even in low-resource classrooms, demonstrating that conceptual mastery of spatial reasoning can scaffold digital CT learning in an equitable and sustainable way.

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