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Computational Thinking in Primary-Level Game-Based Learning: A Bibliometric and Systematic Review of Game Typologies and Computational Thinking Dimensions

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Abstract: ***Objective***: This study examines the development of computational thinking (CT) in the context of game-based learning (GBL) at the primary education level, focusing on research trends, game typologies, and CT dimensions. The objective is to provide a comprehensive and integrated synthesis of how CT is conceptualized and implemented within GBL. ***Method***: A combined approach of bibliometric analysis and systematic literature review (SLR) was employed. Data were collected from the Scopus database and analyzed using Biblioshiny and following PRISMA guidelines. A total of 15 articles met the inclusion criteria and were analyzed. ***Results***: indicate that research on CT in GBL shows a growing but non-linear trend, reflecting an emerging field. Bibliometric network analysis reveals that computational thinking functions as a central node linking key themes such as collaborative learning, artificial intelligence, and primary education, although the thematic structure remains fragmented. In terms of game typologies, digital and programming-based games dominate, while unplugged and hybrid approaches are still limited. Furthermore, four main CT dimensions are identified: computational concepts, computational practices, algorithmic thinking, and computational perspectives; however, most studies emphasize only partial dimensions. ***Novelty***: The novelty of this study lies in its integrated analytical framework that connects bibliometric trends, thematic structures, game typologies, and CT dimensions within a single synthesis. This study highlights the need for more holistic and pedagogically grounded approaches to developing CT through GBL in primary education.

Keywords: Computational Thinking; Game-Based Learning; Primary Education; Bibliometric Analysis; Systematic Literature Review.

Introduction

Computational Thinking (CT) has emerged as a key competency in 21st-century education, driven by the increasing demand for higher-order thinking skills in the digital era and the Fourth Industrial Revolution. In its recent development, CT is no longer viewed merely as a technical skill within computer science; rather, it is conceptualized as a universal cognitive framework encompassing decomposition, abstraction, pattern recognition, and algorithm design to systematically address complex problems (Wing, 2006). Contemporary studies further emphasize that CT plays a critical role in supporting cross-disciplinary problem-solving and logic-based decision-making processes (Yıldız & Poyraz, 2026; Zacharaki & Hadzilacos, 2025).

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In the context of primary education, CT is increasingly recognized as an integral component of 21st-century skills. Recent research indicates that CT has been integrated across various subject domains, including mathematics, science, and technology, through interdisciplinary approaches that emphasize exploration, modeling, and problem-based activities (Gardeli & Vosinakis, 2025; Tang et al., 2020). Moreover, global publication trends demonstrate a significant increase in CT-related studies since 2020, particularly at the primary level, reflecting a shift from content-oriented instruction toward thinking-oriented learning (Mehrvarz et al., 2024).

At the primary school level, CT is often conceptualized as a developmental cognitive process aligned with children's learning characteristics. Young learners have strong potential to develop CT through concrete, exploratory, and contextually meaningful activities. Empirical evidence suggests that CT learning is more effective when embedded in hands-on experiences, game-based environments, and manipulative activities (Mumcu et al., 2023; Yoon & Khambari, 2022). Nevertheless, the implementation of CT in primary education continues to face several challenges, including limited pedagogical strategies, insufficient teacher readiness, and the lack of structured instructional models to support its effective development (Samodra et al., 2025).

One of the most promising approaches to addressing these challenges is Game-Based Learning (GBL). GBL refers to an instructional approach that incorporates game elements to enhance students' motivation, engagement, and overall learning experience (Arrahman et al., 2024; Islam et al., 2024). Empirical evidence suggests that GBL can create interactive and enjoyable learning environments, thereby encouraging active student participation in the learning process (Gardeli & Vosinakis, 2025). In the context of primary education, GBL is particularly advantageous as it aligns with children's developmental characteristics, which emphasize learning through play, exploration, and social interaction.

The rapid advancement of digital technologies has further expanded the scope of GBL into various forms, including digital games, serious games, educational robotics, augmented reality (AR), and unplugged game-based activities. Recent studies indicate a significant increase in the use of game-based approaches in education, particularly within technology- and programming-oriented learning environments (Huang et al., 2023). Moreover, the diversity of game typologies enables the design of adaptive learning experiences that can accommodate different student needs across both digital and non-digital contexts.

Consequently, the integration of CT and GBL has become a central focus in contemporary educational research. Game-based environments provide rich contexts for developing CT, as learners naturally engage in problem-solving, decision-making, and iterative processes that reflect core CT practices such as debugging, algorithm design, and abstraction (Gökçe & Yenmez, 2023; Wu et al., 2024). Empirical studies and meta-analyses consistently report that GBL has a significant positive effect on CT development, particularly in enhancing students' algorithmic thinking, logical reasoning, and problem-solving abilities (Hsu et al., 2022; Kanaki et al., 2022). Additionally, game-based approaches have been shown to increase intrinsic motivation and learner engagement, both of which are critical factors in fostering effective CT learning.

Despite the growing body of literature, several critical gaps remain in the integration of computational thinking (CT) and game-based learning (GBL). First, there is a lack of consistency in how CT dimensions are conceptualized and assessed. While some studies focus narrowly on specific aspects such as algorithmic thinking, others adopt broader and more comprehensive CT frameworks, leading to conceptual and methodological inconsistencies (Alós Cívico et al., 2025; Sungkaew et al., 2022; Yong et al., 2024).

Second, existing research is largely dominated by digital and programming-based games, which limits the exploration of alternative approaches such as non-digital or hybrid game-based learning, particularly in primary education contexts (Gökçe & Yenmez, 2023; Ouahouda et al., 2025; Sarifah et al., 2023). This imbalance suggests that the potential of diverse game modalities in supporting CT development remains underexplored (del Olmo-Muñoz et al., 2023). Third, the integration of GBL with systematic and theory-driven pedagogical models remains relatively limited. As a result, the implementation of CT-oriented learning often lacks a strong instructional foundation, potentially constraining its effectiveness (Yıldız & Poyraz, 2026). In addition, most studies tend to address CT within general K–12 settings, with insufficient attention to the specific characteristics of primary education, where learning design should be more contextualized, exploratory, and aligned with students' cognitive development.

Furthermore, there is a notable scarcity of studies that integrate bibliometric analysis and systematic literature review to simultaneously examine research trends, game typologies, and CT dimensions. This indicates a need for a more comprehensive and integrative approach to better understand the evolving landscape of CT in GBL. In response to these gaps, this study aims to provide a comprehensive synthesis by combining bibliometric analysis and systematic review to examine the development of CT in GBL at the primary education level. Specifically, this study seeks to analyze research trends, identify game typologies, and examine the CT dimensions developed within GBL contexts. The findings are expected to contribute both theoretically and practically by informing the design of more effective learning environments to enhance students' computational thinking.

Based on these considerations, the study is guided by the following research questions:

RQ1: How have publication trends on CT in GBL at the primary level evolved?

RQ2: What does the bibliometric network visualization of keyword co-occurrence reveal?

RQ3: What types of games (game typologies) are used in CT-based GBL research?

RQ4: What CT dimensions are developed in GBL contexts at the primary level?

Method

1. Research design research

This study combines a systematic literature review (SLR) and bibliometric analysis to comprehensively map the development of research on computational thinking within the context of game-based learning in primary education. The SLR is employed to systematically synthesize empirical findings in order to identify research patterns and gaps (Xiao & Watson, 2019), while bibliometric analysis is used to explore publication trends, citation patterns, and the structure of scientific collaboration (Snyder, 2019). The literature selection process follows PRISMA guidelines to ensure transparency and replicability of the study (Suarilah et al., 2026).

2. Data Sources and Search Strategy

Data were retrieved from the Scopus database due to its extensive coverage of reputable international journals and its provision of consistent metadata suitable for bibliometric analysis. The literature search was conducted using the advanced search feature on April 4, 2026, employing a combination of keywords related to computational thinking, game-based learning, and primary education. The search query was constructed using the following syntax:

TITLE-ABS-KEY (("game-based learning" OR "digital game-based learning" OR "educational games" OR "serious games" OR gamification") AND ("computational thinking" OR "algorithmic thinking" OR "problem decomposition" OR abstraction OR "pattern recognition" OR algorithm) AND ("elementary school" OR "primary school" OR "primary education" OR "elementary education" OR "K-6" OR "young learners"))*

The search was limited to peer-reviewed research articles published in English that had reached final publication status and were available in open access, ensuring both the credibility of sources and the availability of full-text data for analysis.

3. Study Selection Procedure

The literature selection process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to ensure transparency and replicability. During the identification stage, a total of 178 records were retrieved from the Scopus database. An initial screening based on document type and inclusion criteria resulted in the exclusion of 134 records, including conference proceedings, conference reviews, book chapters, review articles, and studies that were not in final publication status, not written in English, or outside the specified time frame.

The remaining records were then subjected to a title and abstract screening process. At this stage, studies were evaluated based on their relevance to computational thinking, the use of game-based learning approaches, and their focus on primary or elementary education. Studies that did not meet these criteria were excluded.

The screening stage yielded 44 articles deemed relevant for further assessment. Of these, 40 articles were eligible for full-text retrieval, while 4 were excluded due to limited accessibility (i.e., not available in full-text or not fully open access). During the eligibility stage, 15 articles were selected for in-depth analysis, whereas 25 were excluded because they did not align with the predefined keywords and research focus

Finally, 15 studies met all inclusion criteria and were included in the final analysis. This selection process indicates that, despite a relatively large number of initial publications, only a limited subset specifically addresses computational thinking within the context of game-based learning at the primary education level, highlighting the still limited and focused nature of research in this area. The study selection process is illustrated in the PRISMA flow diagram (Figure 1).

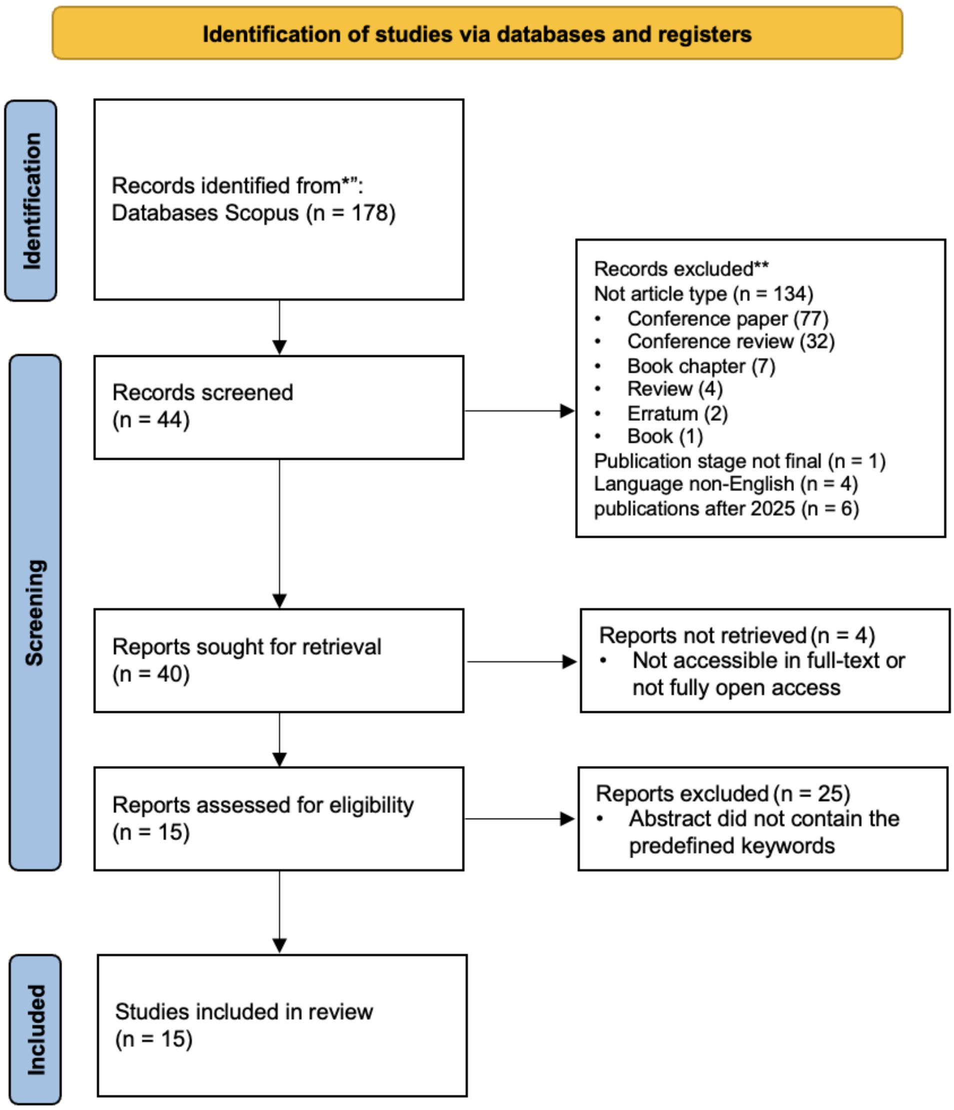

Figure 1. PRISMA 2020 flow diagram of the literature selection process

Data Analysis

1. **Bibliometric Analysis**

Bibliometric analysis was employed to quantitatively map the development of research on computational thinking within the context of game-based learning in primary education. This analysis focused on identifying publication trends and keyword patterns to reveal the intellectual structure and research directions of the field. To enhance interpretability, network visualization was conducted using Bibliometrix, enabling a systematic and comprehensive representation of relationships among research variables. All data were processed using the Biblioshiny package in RStudio with Scopus data in (.bib) format. The results of this analysis were used to address research questions RQ1 to RQ3 in a structured manner.

2. **Systematic Review Analysis**

A systematic literature review (SLR) approach was employed to synthesize empirical findings through data extraction, thematic coding, and narrative synthesis. The analysis focused on 15 selected articles, examining three key aspects: publication trends, game typologies, and computational thinking dimensions. This approach enabled the identification of patterns, variations, and research gaps in a structured and comprehensive manner. Furthermore, it provided a conceptual basis for understanding the relationship between game design and the development of computational thinking, while also highlighting underexplored areas for future research.

Result and Discussion

Results

1. **Characteristics of Included Studies**

Table 1. Characteristics of selected studies on CT in GBL

No	Author (Year)	Country	Sample	Method	Type Game
D1	Gardeli & Vosinakis (2025)	Yunani (Greece)	33 elementary students	Experiment	Tangible Mobile Augmented Reality (TMAR) Game berbasis Student-Generated Challenges (SGC)
D2	Anna & Spyros (2025)	Yunani (Greece)	23 elementary students	Quasi-experimental	Tangible Mobile Augmented Reality (TMAR) collaborative game (ARQuest)
D3	Sun et al. (2025)	China	57 primary school students	True experimental	AI-driven gamified serious game (Strongest Speech Streamer)
D4	(Hsu & Hsu, 2025)	Taiwan	56 sixth-grade students	Quasi-experimental	Board game+AI-based game (GAID+robot control game)
D5	Ouahouda et al. (2025)	Marocco	60 primary school students	mixed-methods	Game-Based Learning berbasis Scratch (visual programming, game creation)
D6	Mohamed et al. (2024)	Malaysia	90 primary school students	Kuantitatif (PLS-SEM / Structural Equation Modeling)	Game-Based Learning (digital/educational games mathematics)
D7	Barradas et al. (2024)	Portugal, Kroasia, Italia, Lithuania, Turki	350 primary school students	Quantitative	Educational Robotics + Gamification (Arduino-based robot + narrative game)

D8	Chen et al. (2023)	Taiwan	158 primary school students	Quasi-experimental	Game-based learning (Code.org, puzzle-based visual programming)
D9	del Olmo-Muñoz et al. (2023)	Spain	82 primary school students	Quasi-experimental	Gamification (shallow vs deep gamification, blended unplugged & plugged activities, Code.org+MyClassGame)
D10	Huang et al. (2023)	Taiwan	51 elementary students	Quasi-experimental	Game-Based Learning (AR Board Game "Coding Ocean")
D11	(Hsu et al. (2022)	Taiwan & Singapore	46 elementary students	Quasi-experimental	Game-Based Learning Social Robot (SR-integrated activity: story play, coding, gameplay)
D12	(Sungkaew et al. (2022)	Thailand	83 elementary students	Design & Development Research (GDSE model)	Digital Educational Game (maze/pathfinding, Scratch-based, single-player)
D13	Kanaki et al. (2022)	Yunani (Greece)	435 elementary students	Quantitative	Game-based learning (digital jigsaw puzzle via PhysGramming platform)
D14	Zapata-Caceres et al. (2021)	Spain	176 elementary students	Exploratory case study	Digital game-based programming environment (BAC - Blue Ant Code, visual block-based, collaborative & individual mode)
D15	Panskyi & Rowińska (2021)	Poland	329 elementary students	Descriptive quantitative study	Digital Game-Based Learning (DGBL) berbasis programming, robotics, dan electronics (Scratch, LEGO EV3, Arduino)

Based on the literature selection process, a total of 15 articles from the Scopus database were analyzed to identify the characteristics of research on computational thinking within the context of game-based learning at the primary education level. Overall, the studies reflect diverse geographical contexts, with a notable concentration in Asia (e.g., Taiwan, China, Malaysia) and Europe (e.g., Greece, Spain, Portugal), indicating growing global attention to the integration of CT in game-based learning environments.

From a methodological perspective, most studies employed quasi-experimental and quantitative approaches, while a smaller number adopted true experimental designs, mixed-methods, and design and development research. This pattern suggests that research in this field is largely oriented toward evaluating the effectiveness of game-based learning interventions in enhancing students' computational thinking.

In terms of game typologies, a wide range of approaches is evident, including augmented reality games, AI-driven serious games, educational robotics, board games, and digital programming environments such as Scratch and Code.org. Notably, there is an increasing integration of advanced technologies, particularly artificial intelligence and robotics, reflecting a shift from conventional instructional approaches toward more interactive and adaptive learning ecosystems.

Overall, these findings indicate that the implementation of game-based learning for developing computational thinking in primary education is not only expanding in volume but also diversifying in methodological approaches and technological design, although it remains largely dominated by digital and programming-based approaches.

2. RQ1. Publication trends on CT in GBL at the primary level

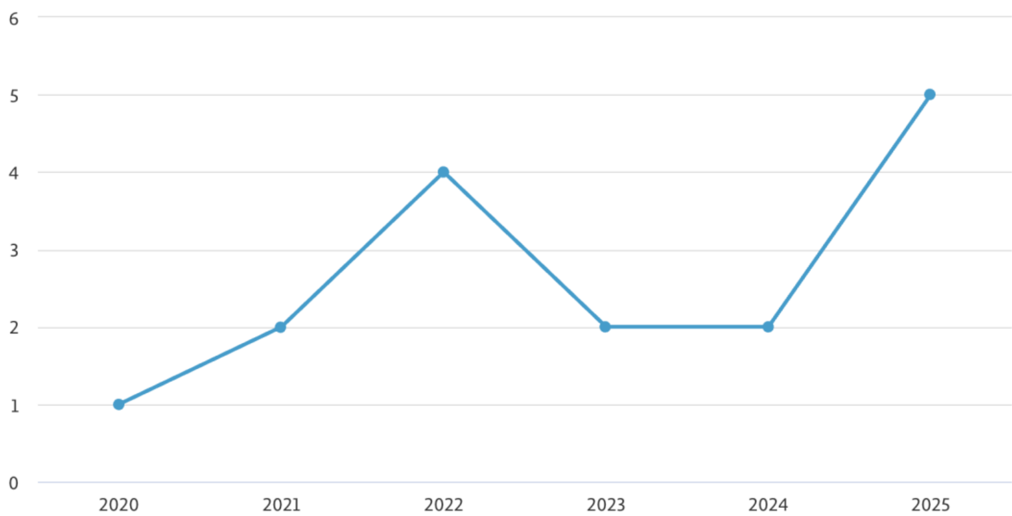

Figure 2. Publication Trends in Scopus

The figure illustrates the publication trends of computational thinking research within the context of game-based learning at the primary education level from 2020 to 2025, showing an overall upward trajectory despite some fluctuations. Following a notable increase in 2022, the number of publications remained relatively stable in 2023-2024 before reaching its peak in 2025.

Overall, this trend suggests that the field remains in an emerging stage, yet demonstrates growing academic interest. This growth is closely associated with the increasing integration of advanced technologies, such as artificial intelligence, augmented reality, and educational robotics, into learning environments.

3. RQ2. Bibliometric Network Visualization of Keyword Co-occurrence

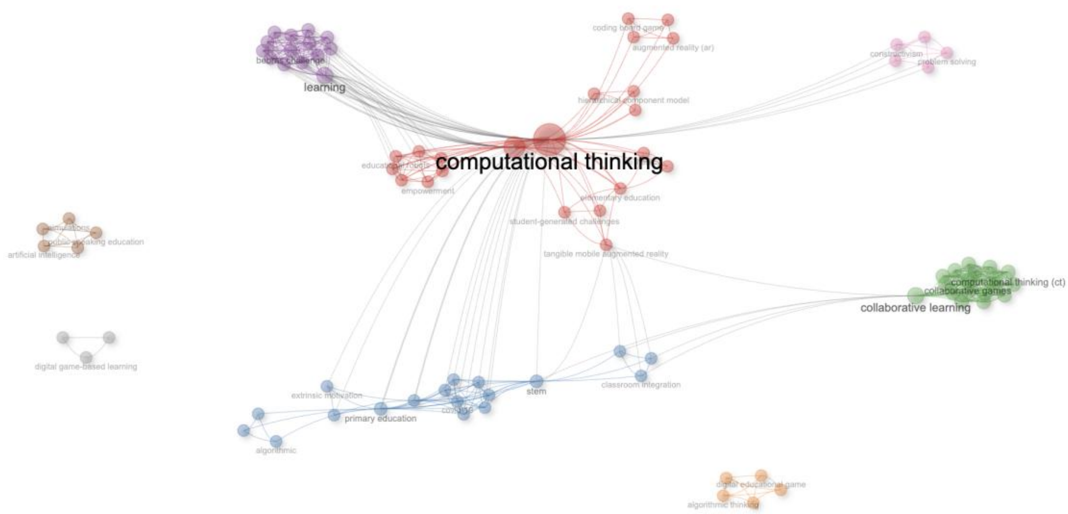

Figure 3. The result of Bibliometric Network Visualization

The keyword co-occurrence analysis using Biblioshiny reveals that computational thinking functions as the central node connecting multiple research themes within the context of game-based learning. These interconnections form several major clusters that represent emerging research directions in the field.

The first cluster highlights the relationship between computational thinking and educational concepts such as learning and education, indicating a strong emphasis on the pedagogical integration of CT. Another cluster reflects the linkage between CT and advanced technologies, including augmented reality and artificial intelligence, suggesting a shift toward the adoption of innovative technological tools in game-based learning design. Additionally, clusters associated with collaborative learning and problem solving underscore that CT development extends beyond technical skills to include social interaction and higher-order cognitive processes.

Furthermore, clusters such as primary education and classroom integration indicate an increasing focus on the practical implementation of CT within real classroom contexts. However, some clusters appear relatively isolated and weakly connected, suggesting a degree of thematic fragmentation and a lack of cohesive integration among technological, pedagogical, and CT-related dimensions. Overall, this bibliometric mapping demonstrates that research on CT in game-based learning is evolving along multiple trajectories. Nevertheless, the field still requires stronger conceptual integration to establish a more cohesive and comprehensive research framework.

4. RQ3. Game Typologies in CT-Based Game-Based Learning

Based on the analysis of 15 selected studies, the types of game-based learning employed demonstrate considerable diversity, with a clear dominance of digital and programming-based games. Most studies utilize digital programming environments such as Scratch, Code.org, and other visual programming platforms, primarily aimed at developing algorithmic thinking and problem-solving skills.

In addition, there is a notable trend toward the integration of advanced technologies, including augmented reality (AR), artificial intelligence (AI), and educational robotics, which are leveraged to create more interactive and adaptive learning experiences. Several studies also combine digital approaches with unplugged or board games, as well as gamification strategies, reflecting efforts to design more contextualized and flexible learning environments.

Overall, these findings indicate that game-based approaches for developing CT are evolving not only in terms of technological sophistication but also in the diversification of formats and instructional designs. However, the field remains largely dominated by digital, coding-oriented ecosystems.

5. RQ4. Computational Thinking Dimensions in Game-Based Learning

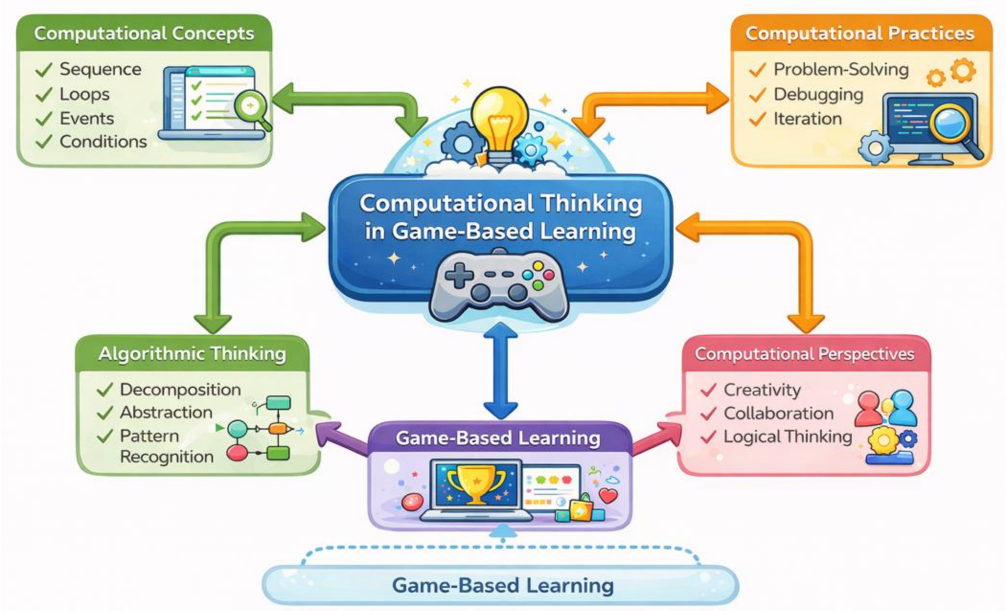

Figure 4. Dimentions of Computational Thinking in Game-Based Learning

This figure 4. presents a conceptual synthesis derived from 15 SLR articles, illustrating the interrelationships among computational thinking (CT) dimensions within the context of game-based learning (GBL) in primary education. The analysis indicates that CT develops through the dynamic interaction of computational concepts, computational practices, algorithmic thinking, and computational perspectives.

Progressively, foundational concepts such as sequence and loops serve as the basis, followed by iterative practices such as problem-solving and debugging. These processes are subsequently integrated through algorithmic thinking, ultimately contributing to the development of broader competencies, including creativity and collaboration. Overall, the findings highlight that CT development in GBL is inherently multidimensional and highly interconnected.

Discussion

The findings of this study provide a comprehensive overview of the development of computational thinking (CT) within the context of game-based learning (GBL) in primary education, analyzed through a combination of bibliometric analysis and a systematic literature review (SLR). Overall, the results indicate that this field is in an emerging yet consolidating phase, characterized by increasing research interest alongside persistent conceptual and methodological fragmentation.

Figure 1 illustrates the publication trend related to RQ1, showing that a general upward trajectory in recent years, albeit non-linear. The observed increase, particularly in the most recent years, reflects growing scholarly attention to the integration of CT within GBL, in line with advancements in educational technologies such as artificial intelligence, augmented reality, and educational robotics (Barradas et al., 2024; Gardeli & Vosinakis, 2025; Sungkaew et al., 2022; Yoon & Khambari, 2022). These findings are consistent with prior research highlighting digital technology integration as a key driver in expanding CT implementation in primary education. However, the fluctuating pattern also indicates that the field has not yet reached conceptual maturity, remaining in a phase of ongoing exploration of diverse pedagogical approaches and innovations.

Based on Figure 3 related to RQ2, the bibliometric network visualization of keyword co-occurrence reveals that computational thinking functions as a central node connecting multiple research themes. The identified clusters reflect three dominant directions: the integration of CT within educational practices (learning and education), the incorporation of advanced technologies such as AI and AR, and the emphasis on social and cognitive processes such as collaborative learning and problem solving(Anna & Spyros, 2025; Zapata-Caceres et al., 2021). Nevertheless, the relatively fragmented network structure suggests that these themes are not yet fully integrated at a conceptual level. This finding aligns with previous studies indicating that CT research still faces challenges in establishing a coherent and unified theoretical framework (Panskyi & Rowińska, 2021). Thus, the bibliometric analysis not only maps the thematic structure of the field but also highlights the need for stronger theoretical integration.

In addressing RQ3, Table 1 show that the SLR findings reveal that the types of games employed in CT-based GBL research are highly diverse, yet predominantly centered on digital and programming-based environments, such as Scratch, Code.org, and visual programming platforms (Ouahouda et al., 2025; Sarifah et al., 2023). In addition, there is a growing tendency to integrate advanced technologies, including augmented reality (AR), artificial intelligence (AI), and educational robotics, which enable more interactive and adaptive learning experiences (Auliya et al., 2026; Barradas et al., 2024; Hsu & Hsu, 2025). These findings reinforce prior research indicating that digital game-based learning has become the dominant approach in fostering CT development. However, this dominance also highlights a limited exploration of alternative approaches, such as unplugged games or context-based learning, which hold significant potential for primary education, particularly in resource-constrained settings (Hu & Wang, 2024).

Regarding RQ4, Figure 4 shows that the CT dimensions developed within GBL contexts encompass four main components: computational concepts, computational practices, algorithmic thinking, and computational perspectives (Benvenuti et al., 2023; Rachel, 2023). These dimensions evolve progressively and are inherently interconnected, beginning with foundational concepts such as sequence and loops, followed by iterative practices such as debugging and problem solving, which are then integrated through algorithmic thinking, ultimately leading to the development of broader competencies such as creativity and collaboration (Anna & Spyros, 2025). This finding aligns with the CT framework proposed by Brennan and Resnick, as well as empirical studies emphasizing the importance of integrating conceptual, practical, and perspective-based dimensions in CT development.

Nevertheless, the results also indicate that most studies tend to focus on specific dimensions-particularly algorithmic thinking without adopting a holistic approach that integrates all CT components. This suggests a gap in instructional design, where CT development is often treated in a fragmented manner and does not fully reflect the complexity of the construct. Overall, the integration of bibliometric and SLR findings demonstrates that, despite the quantitative growth of CT research within GBL, the field continues to face challenges related to conceptual consistency, diversification of game approaches, and the comprehensive integration of CT dimensions. Accordingly, this study underscores the need for more integrated approaches that not only leverage technological advancements but also align game design with pedagogical frameworks and CT dimensions in a systematic manner.

Building on these findings, this study contributes both theoretically and practically by advancing a more integrated understanding of computational thinking within game-based learning contexts. Theoretically, the study extends existing frameworks by demonstrating how different computational thinking dimensions can be systematically connected through game typologies, addressing the fragmentation observed in prior research. This integration provides a clearer conceptual structure for understanding how computational thinking develops across multiple dimensions rather than in isolation.

Practically, the findings offer a foundation for designing more effective learning environments by aligning specific types of game-based learning with targeted computational thinking processes. This enables educators and instructional designers to move beyond general engagement-oriented approaches and toward more purposeful, cognitively grounded implementations that support the holistic development of computational thinking in primary education.

Despite these contributions, this study has several limitations. First, the analysis was restricted to publications indexed in the Scopus database, which may not fully represent all relevant studies in this field. Second, the inclusion criteria were limited to English-language publications, potentially excluding valuable research published in other languages. Third, the focus on primary education and specific keywords related to computational thinking and game-based learning may have narrowed the scope of the findings. Finally, as this study relies on secondary data from published literature, the results are dependent on the quality and reporting of the selected studies.

Therefore, the primary contribution of this study lies in offering a synthesized framework that connects research trends, thematic structures, game typologies, and CT dimensions into a unified analytical perspective. This integrated approach provides a stronger foundation for designing game-based learning environments that are not only technologically effective but also pedagogically meaningful in fostering computational thinking among primary school students.

The findings of this study offer several important implications. For educators, the proposed framework can serve as a guide for selecting and designing game-based learning activities that explicitly incorporate key computational thinking dimensions, such as decomposition, abstraction, and algorithmic thinking. For researchers, this study highlights the need for further empirical investigations to examine the alignment between game mechanics and computational thinking processes across diverse educational contexts. For curriculum developers and policymakers, the results emphasize the importance of integrating computational thinking within structured pedagogical frameworks to ensure its systematic implementation in primary education. Additionally, future game-based learning designs should move beyond technological novelty and prioritize meaningful pedagogical integration to enhance students’ higher-order thinking skills.

Conclusion

This study provides a comprehensive synthesis of the development of computational thinking (CT) within game-based learning (GBL) in primary education by integrating bibliometric analysis and a systematic literature review. The findings reveal that, despite increasing research interest, the field remains in an early stage of development with fragmented thematic structures and limited conceptual integration.

CT is predominantly approached through specific dimensions, particularly algorithmic thinking, rather than as a holistic construct. Similarly, game-based learning designs are largely dominated by digital and programming-based approaches, with limited diversification into more contextual and pedagogically integrated models.

Accordingly, this study contributes by proposing an integrated analytical framework that connects research trends, thematic structures, game typologies, and CT dimensions. This framework emphasizes the need to move beyond technology-driven approaches toward more holistic and pedagogically grounded designs. Future research should focus on developing and empirically validating integrated instructional models that align diverse game typologies with comprehensive CT frameworks in authentic primary education contexts.

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