FROM THE BOARD TO THE MIND: THE ROLE OF MODERN BOARD GAMES IN FOSTERING COMPUTATIONAL THINKING IN PRIMARY EDUCATION

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Abstract

This study analyzed the role of Modern Board Games (MBG) as pedagogical tools for developing Computational Thinking (CT) in primary school students. A mixed-methods research design was employed with a sample of 40 students. Quantitative results, obtained through pre-test, midterm test, and post-test, revealed significant differences in the scores of the experimental group compared to the control group. Qualitative analysis, based on observations and field notes, revealed that the game mechanics enabled students to construct computational strategies promoting greater engagement. The study concludes that the use of Modern Board Games (MBG) can represent an innovative and effective approach for fostering CT in primary education.

Introduction

Computational Thinking (CT) first gained significant attention within the academic community in 2006. Jeannette Wing, a Computer Science professor at Columbia University in New York, highlighted CT as a fundamental skill for everyone, essential in today's world. She argued that CT should be considered a core competency, just like learning to read, write, or do arithmetic (Wing, 2006). Wing's call to action prompted an immediate response from educators, researchers, and institutions, who, over the years, have engaged in ongoing debate on the most effective ways to foster CT skills among students.

Today, a growing number of schools around the world are showing interest in integrating CT into their curricula. In most cases, this integration is closely tied to programming and computer science (Bocconi et al., 2022). Indeed, numerous initiatives aimed at promoting CT have emerged across all levels of compulsory education, including early childhood education. These efforts reflect not only the increasing recognition of CT's importance, but also the consensus that it should be cultivated from a young age through to higher education (Bers, 2023; Relkin et al., 2023; Yang et al., 2023).

Despite having emerged in 2006, CT remains an evolving and dynamic educational topic. The number of published studies on CT began to rise sharply after 2017, particularly within the field of educational research (Chen et al., 2023). Thematic phases in the field of CT could be grouped into the following categories: (1) the early work on computational education (Papert, 1993); (2) the emergence of the first CT definitions (Wing, 2006, 2008; Lee et al., 2011); (3) the identification of CT characteristics (Barr & Stephenson, 2011; Brennan & Resnick, 2012; Grover & Pea, 2017; Shute et al., 2017); and (4) the rapid growth of empirical and review studies on CT (Bers, 2020; Moreno-León et al., 2015).

Within the diverse landscape, CT has increasingly been introduced into primary education systems around the world through three main pedagogical approaches: programming, educational robotics, and Unplugged Activities (UA). Unplugged Activities were initially designed to introduce students to computer science concepts without the use of digital devices (Bell & Vahrenhold, 2018). However, they are now widely used in various contexts to support CT development (Munasinghe et al., 2023). These activities may include puzzles, magic tricks, or games, and are intended to cultivate the type of reasoning typically used by computer scientists through hands-on manipulation of physical materials such as paper, cards, or tokens. Within this scope, board games (BG) also play a prominent role (Menon et al., 2019).

Currently, board games are being increasingly explored as a resource to support diverse forms of learning, including CT (Bayeck, 2024; Machuqueiro & Piedade, 2022; Sousa, 2023). Still, despite their growing acceptance, the use of board games as a form of unplugged activity remains limited when compared to other CT-related approaches (Machuqueiro & Piedade, 2022). Considering that, the present study aims to address the following two research questions:

- (RQ1) What is the impact of using Modern Board Games on the development of Computational Thinking in primary school students?
- (RQ2) How do the mechanics of Modern Board Games influence the development of Computational Thinking?

This research proposes the use of MBG in classroom settings to foster CT in first-cycle primary education (1st to 4th grade). The study involved structured gameplay sessions and guided exploration of a carefully selected set of games, with the goal of evaluating the effectiveness of this approach through pre- and post-tests to assess students’ Computational Thinking skills.

Computational Thinking Concepts

Computational Thinking (CT) has emerged as a key 21st-century competence, increasingly recognized as fundamental to problem-solving and the understanding of both natural and artificial systems through principles of computer science (Wing, 2006; Brennan & Resnick, 2012).

Although the term "Computational Thinking" gained prominence following Wing’s (2006) work, its conceptual roots can be traced back to the seminal contributions of Seymour Papert. In Mindstorms: Children, Computers, and Powerful Ideas (1980), Papert introduced a constructivist approach to learning with computers, emphasising the importance of learners actively constructing knowledge through the design and debugging of programs using the LOGO programming language. Papert (1980) saw programming not merely as a technical skill but as a way of thinking that could empower children to approach problems systematically, creatively, and reflectively.

Wing (2006) later defined CT as a human intellectual skill involving abstraction, decomposition, automation, and iterative problem-solving, arguing that CT should be taught alongside foundational skills such as reading and mathematics. Her work sparked widespread academic interest and was pivotal in framing CT as a broadly applicable cognitive tool.

Expanding upon this foundation, Brennan and Resnick (2012) proposed a three-dimensional model that remains widely cited in the literature:

- **Computational Concepts:** such as sequences, loops, parallelism, events, conditions, operators, and data;
- **Computational Practices:** including iterative development, testing and debugging, reuse and remixing, abstraction, and modelling;
- **Computational Perspectives:** encompassing students' self-expression, empowerment, and engagement with technological artefacts and their social context.

Shute et al. (2017) contributed a complementary model focusing on six core dimensions of CT applicable across subject areas: Abstraction; Decomposition; Algorithm design; Debugging; Iteration; and Generalization. This model has proven particularly valuable in the design of assessment tasks and instructional strategies aimed at evaluating and fostering CT across educational levels.

Kafai et al. (2020) later proposed a more holistic perspective, aligning CT with Simon Sinek's "Golden Circle" theory (Sinek, 2009). Their framework integrates three layers:

- **Cognitive:** aimed at developing students' understanding of concepts, practices, and perspectives necessary for future careers;
- **Contextual:** emphasising authorship, identity, and the creation of meaningful computational artefacts;
- **Critical:** rooted in critical thinking and oriented towards social justice and transformative practice.

From a curricular standpoint, Bocconi et al. (2022) offered a consolidated overview of key concepts directly related to CT development, including: abstraction, data analysis, decomposition, pattern recognition, system thinking, algorithmic thinking, simulation, modeling, and Boolean logic.

Collectively, these dimensions and practices underscore the multifaceted nature of CT, which spans technical, cognitive, and socio-cultural domains. As Grover and Pea (2017) assert, CT is not limited to programming; rather, programming serves as one expression of the deeper thinking processes involved in CT.

In this study, these theoretical perspectives support the understanding that CT can be fostered through a range of pedagogical strategies — including the use of modern board games — which provide authentic contexts for engaging in problem-solving, abstraction, and simulation activities.

Modern Board Games and Computational Thinking Development

Modern Board Games (MBGs) have emerged as powerful analog tools for supporting the development of Computational Thinking (CT), particularly in primary education settings. While traditionally overshadowed by digital approaches such as coding and robotics, MBGs provide unplugged yet cognitively rich environments in which learners engage with core CT processes through gameplay (Bayeck, 2024).

These games, governed by structured rules and complex systems, serve as fertile ground for the expression of CT dimensions, such as abstraction, algorithm design, decomposition, pattern recognition, conditional logic, and simulation (Berland & Lee, 2011; Tsarava et al., 2019; Machuqueiro & Piedade, 2023). Empirical studies reveal that the type of mechanics embedded in a board game plays a decisive role in determining which dimensions of CT are activated during gameplay.

In the CTLM-TM framework (Computational Thinking Learning Model for Tabletop Mechanics), developed by Machuqueiro and Piedade (2023), specific types of board game mechanics were mapped to CT dimensions. The following are some key associations drawn from this model and corroborated by empirical data:

- **Resource Management & Planning Mechanics** → Associated with abstraction and algorithmic thinking, as players must anticipate outcomes and optimize decisions.
- **Conditional Play (if-then rules, action resolution)** → Encourages logical reasoning and conditional logic akin to control structures in programming.
- **Simulation and scenario exploration** → Activates debugging, simulation, and iteration, as players test strategies and refine them over multiple rounds.
- **Pattern Recognition and Set Collection** → Directly linked to the CT dimension of pattern recognition and generalisation (Tseng et al., 2019).

- **Tile Placement and Spatial Strategy** (e.g., in games like Rossio) → Supports decomposition, abstraction, and systems thinking, especially as players must visualise outcomes spatially and temporally.

Materials and Methods

This study adopted an embedded, concurrent mixed-methods design (Creswell, 2009), incorporating an experimental group (EG) and a control group (CG) to evaluate the development of Computational Thinking (CT) in students from the first cycle of basic education (grades 1st to 4th). The sample consisted of 40 third-grade students, aged between 8 and 10 years, divided into two groups (experimental and control). Sixty-minute sessions were integrated into the curriculum of an Information and Communication Technologies (ICT) project and were supervised by both the researcher and the classroom teacher.

The experimental design followed the steps outlined in Table 1, for the experimental group. The control group developed a set of unplugged pedagogical activities selected by the classroom teacher.

Table 1

Methodological Design of the Study for the Experimental Group

MBGs for CT	Pre-Test	MBG sessions	Mid-Test	MBG sessions	Post-Test	Analysis of Results
• Systematic Analysis of Modern Board Games • Final Selection of the games for the Study • *King of Dice: The Boardgame* • *Rossio* • *PreHistorias* • *Festival*	• Beginners Computational Thinking Test (BCTt) • 1 session • 60 minutes	• King of Dice: The Boardgame and Rossio • 8 sessions • 8 weeks • Direct observation of gameplay Collection of field notes	• Beginners Computational Thinking Test (BCTt) • 1 session • 60 minutes	• PreHistorias and Festival • 8 sessions • 8 weeks • Direct observation of gameplay Collection of field notes	• Beginners Computational Thinking Test (BCTt) • 1 session • 60 minutes	• Analysis of quantitative data derived from the administration of BCTt • Content Analysis, with coding of field notes based on categories

The Beginners Computational Thinking Test (BCTt) (Zapata-Cáceres, et al., 2021) was used to measure CT skills and it was administered as a pre-test, midterm test, and post-test. The BCTt consists of 25 multiple-choice questions with progressively increasing complexity, related to Computational Thinking (CT) concepts as proposed by Brennan and Resnick (2012) and Grover and Pea (2017), such as sequences, loops (including simple and nested loops), and conditionals (including simple, compound, and while conditionals). The test also partially addresses several CT practices (incremental and iterative, testing and debugging, reusing and remixing, abstracting and modularising) observed during the problem-solving process. All these aspects encompass the CT skills outlined by Dagiene et al. (2017), which, in this specific context, can be assessed through qualitative data obtained from observations conducted during the sessions with MBG.

Qualitative data were collected through direct observations and field notes during the sessions, enabling the identification of CT dimensions explored through students' interactions with the board games. The dimensions analyzed included abstraction, algorithms, distributed computing, decomposition, debugging, conditional logic, incremental thinking, pattern recognition, and simulation.

The MBG were selected based on specific criteria and according to its mechanics, using the CTLM-TM model (Machuqueiro & Piedade, 2024), which guides the selection of games capable of fostering Computational Thinking (CT) skills (Englestein & Shalev, 2022; Machuqueiro & Piedade, 2023). Four games were used (Table 2) to promote the development of CT. Statistical techniques were used to analyse quantitative data, particularly to compare the performance between the groups through the application of the Student t-test. At the same time, qualitative data were categorised according to the selected dimensions of CT observed (Dagiene et al., 2017), and content analysis techniques were used (Bardin, 2016).

Table 2

Analysis of the Selected Modern Board Games using the CTLM-TM Model

<table>
<tr><th>Board Game</th><th>CT Learning Mechanics</th><th>MBG Mechanics</th></tr>
<tr><td>King of Dice: The Board Game (KDB)</td><td rowspan="4">Logical Reasoning
Algorithmic Thinking
Debugging
Simulation
Data Analysis
Pattern Recognition
Object-Oriented Programming
Abstraction
Decomposition
Evaluation
Incremental Thinking;
Modeling
Conditional Logic.</td><td rowspan="4">Turn-Based
Cooperation
Worker Placement/ Resource Management
Hand Management
Simultaneous Actions
Pattern Building
Action Queues
Simulation
Modular Board/ Tile Allocation
Real-Time</td></tr>
<tr><td>Rossio (ROS)</td></tr>
<tr><td>PreHistorias (PHI)</td></tr>
<tr><td>Festival (FES)</td></tr>
</table>

Results

The experimental intervention consisted of weekly 60-minute sessions, utilising each of the selected games over a four-week period. The pre-test was administered before the start of the intervention, the intermediate test was conducted after eight weeks, and the post-test was administered at the end of the process. The following figures 1 and 2 illustrate some of the game-based sessions carried out in the classroom, organised into several groups of students.

Figure 1

Setup of the Modern Board Games King of Dice: The Board Games and Rossio

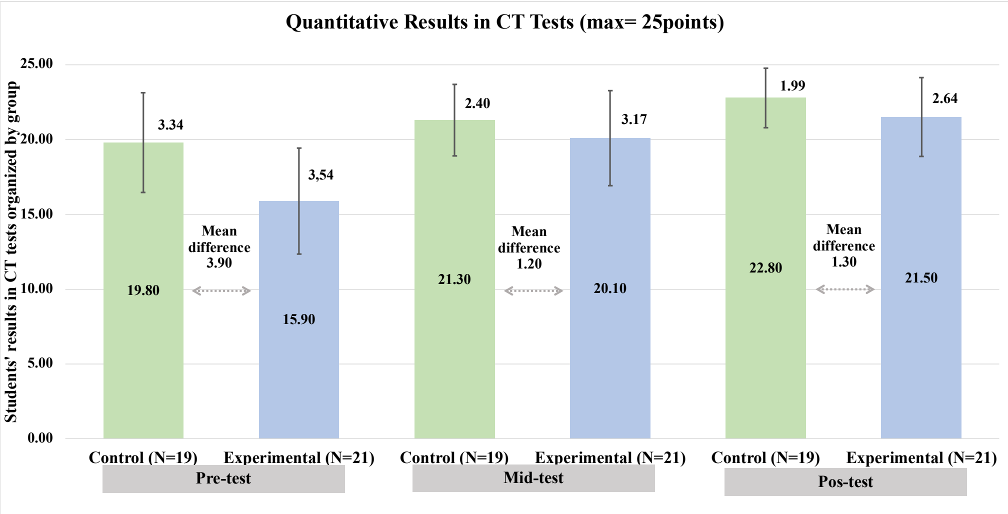
Figure 2

Setup of the Modern Board Games PreHistorias and Festival

The first research question aimed to examine the impact of using modern board games on the development of Computational Thinking in primary school students. The analysis of the results from the Computational Thinking tests indicates a positive impact on students' competencies, particularly in the experimental group (Figure 3). This group showed an increase of 5.66 points, representing a percentage gain of 35.68%, compared to the pre-test and post-test results. In contrast, the control group recorded a less significant improvement of only 2.95 points. After the administration of the pre-test, it was observed that there was no equivalence between the groups, with one group scoring, on average, 3.90 points higher than the other. The comparative analysis of means using the Independent Student's t-test indicated that this difference was statistically significant ($t(38) = -3.65$; $p = <0.001$). Given that the class groups had been pre-established by the school, the decision was made to conduct the intervention with the group that had demonstrated lower initial performance.

Figure 3

Students' results in Computational Thinking tests calculated for the experimental group and the control group. Values are presented as Mean ± Standard Deviation



In the intermediate test conducted eight weeks after the start, a significant improvement was observed in the experimental group's results (M=21.30; +5.4), which approached the performance of the control group (M=20.10; +0.3). The average difference between the groups was only 1.20 points. In other words, following the pedagogical implementation of the first two games, the groups became equivalent in terms of the Computational Thinking competencies demonstrated in the test. The comparative analysis of mean scores from the intermediate test revealed differences that were not statistically significant.

Finally, following the conclusion of the pedagogical intervention, the post-test results showed a slight improvement compared to the intermediate test (experimental group: +1.4; control group: +1.5), with a non-significant mean difference of 1.30 points between the groups ($t_{(38)} = -1.70$; $p = 0.05$).

To address the research question, a further comparison was conducted between each group's pre-test and post-test results using the paired samples Student's t-test, which allows for the comparison of results from the same subjects over time. As previously mentioned, the intervention enabled students in the experimental group to improve their scores by 5.66 points. The comparative analysis of means revealed that this difference was statistically significant ($t(20)=9.59; p<0.001$), with an effect size of 2.09 calculated using Cohen's *d*. The control group showed a smaller increase compared to their initial results, with an improvement of only 2.95 points. The comparative analysis of means indicated that this difference was also statistically significant ($t(18)=3.77; p<0.001$; however, the effect size was smaller ($d=0.86$), reflecting a lower magnitude of impact.

The evidence highlights the potential of the selected modern board games in supporting the development of Computational Thinking concepts proposed by Brennan and Resnick (2012).

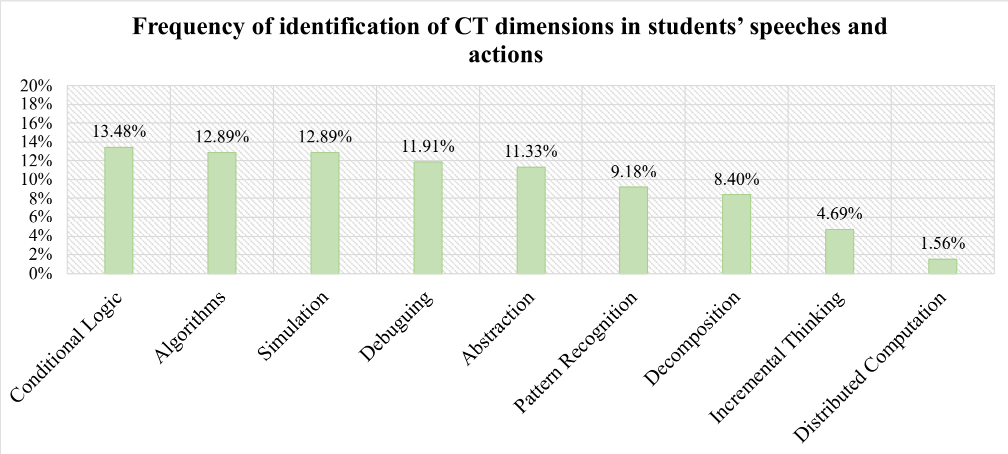
To address the second research question, "How do the mechanics of Modern Board Games influence the development of Computational Thinking?", a content analysis was conducted on field notes and the students' recorded discourse during the gameplay sessions. Based on a predefined category framework, the analysis aimed to identify evidence of the presence of different dimensions of Computational Thinking in students' discussions while solving problems and engaging with game scenarios. Figure 4 presents the frequencies with which each dimension of Computational Thinking was identified, highlighting "Conditional Logic" (13.48%), "Algorithms" (12.89%), "Simulation" (12.89%), "Debugging" (11.91%), and "Abstraction" (11.33%). The following segment presents an example of a dialogue from a group of students in which the presence of "Simulation" actions can be identified during one of the games. In this dialogue, the students/players engaged in hypothetical discussions about possible actions and their potential outcomes.

> ***Mike.LQ:*** *I can already see it coming…*
> ***Kilo.IM:*** *What?*
> ***Mike.LQ:*** *What you're going to do… you're going to take one of mine…*
> ***Kilo.IM:*** *I don't know… I could take Oscar.MA's piece — it's in the middle and close to the flames. I don't have any flames yet.*
> ***Oscar.MA:*** *But he has more points and more castles… that doesn't really make sense…*
> ***Kilo.IM:*** *Actually, it does. I won't fall behind him, and you'll be left without castles.*
> ***Oscar.MA:*** *Right… (showing some discontent).*
> ***Kilo.IM:*** *But no, I'll place it here… I'll take this blue one and stay near a castle that's already mine. That way, I score more points. If I placed it there, I'd end up tied.*
> ***Mike.LQ:*** *Why? Over there you'd also be close to one of yours… and you'd already said it was his.*
> ***Kilo.IM:*** *But you've got more points and you're ahead. If I take Oscar.MA's piece, I tie with you. But if I take this blue one here (pointing to the tile he intended to swap), I move into first place. I could also take*

one from there, so you'd have fewer points… but if I manage to get an ice tile here, I get closer to a line of four in a row.

Figure 4

Frequency of identification of CT dimensions in students' speeches and actions



The main findings of the study highlight the potential of modern board games to provide meaningful challenges and strategic opportunities that foster the development of Computational Thinking. These results are consistent with several studies that have examined the use of modern board games as pedagogical tools for promoting this type of competence (Bayeck, 2024; Berland & Duncan, 2016; Tsaraya et al., 2019). According to Somma (2020), board games are computational artefacts, particularly effective in developing Computational Thinking, as they are rich in variables and function as authentic software systems.

Conclusions

These findings suggest that integrating modern board games into classroom practice can serve as an effective strategy to support the development of Computational Thinking in primary education. By engaging students in problem-solving, planning, and simulation tasks within game-based contexts, educators can create authentic learning environments that align with several Computational Thinking skills.

Future research could further explore which game mechanics are most effective in fostering specific dimensions of Computational Thinking, as well as investigate the long-term impact of sustained game-based interventions across diverse educational settings and student populations.

Notes

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References

Bardin, L. (2016). *Análise de conteúdo*. São Paulo, SP: Edições 70.

Barr, V., & Stephenson, C. (2011). Bringing computational thinking to K-12: What is involved and what is the role of the computer science education community? *ACM Inroads*, *2*(1), 48–54. https://doi.org/10.1145/1929887.1929905

Bayeck, R. Y. (2024). Understanding computational thinking in the gameplay of the African Songo board game. *British Journal of Educational Technology, 55*(1), 259-276. https://doi.org/10.1111/bjet.13353

Bell, T., & Vahrenhold, J. (2018). CS unplugged—How is it used, and does it work? In Böckenhauer, HJ., Komm, D., Unger, W. (Eds.), *Adventures between lower bounds and higher altitudes*. *Lecture Notes in Computer Science, Vol. 11011*. Springer International Publishing. https://doi.org/10.1007/978-3-319-98355-4_29

Berland, M., & Duncan, S. (2016). Computational thinking in the wild: Uncovering complex collaborative thinking through gameplay. *Educational Technology, 56*(3), 29–35.

Berland, M., & Lee, V. R. (2011). Collaborative strategic board games as a site for distributed computational thinking. *International Journal of Game-Based Learning, 1*(2), 65–81. https://doi.org/10.4018/ijgbl.2011040105

Bers, M. (2020). *Coding as a Playground*. Routledge, Taylor& Francis Group.

Bers, M. (2023). El desarrollo de Scratch-Jr: El aprendizaje de programación en primera infancia como nueva alfabetización [The development of Scratch-Jr : Programming learning in early childhood as a new literacy]. *Virtualidad, Educación y Ciencia*, *14*(26), 43-62.

Brennan, K., & Resnick, M. (2012, April 13–17). New frameworks for studying and assessing the development of computational thinking (Vol. 1, 25 pp.). In *Proceedings of the 2012 Annual Meeting of the American Educational Research Association, Vancouver, Canada (Vol. 1)* p. 25. http://scratched.gse.harvard.edu/ct/files/AERA2012.pdf

Bocconi, S., Inamorato dos Santos, A., Chioccariello, A., Cachia, R., Kampylis, P., Giannoutsou, N., Dagienė, V., Punie, Y., Wastiau, P., Engelhardt, K., Earp, J., Horvath, M., Jasutė, E., Malagoli, C., Masiulionytė-Dagienė, V., & Stupurienė, G. (2022). Reviewing computational thinking in compulsory education: State of play and practices from computing education. In A. Inamorato dos Santos, R.

Cachia, N. Giannoutsou, & Y. Punie (Eds.) *Publications Office of the European Union 2022*. https://data.europa.eu/doi/10.2760/126955

Chen, H. E., Sun, D., Hsu, T.-C., Yang, Y., & Sun, J. (2023). Visualising trends in computational thinking research from 2012 to 2021: A bibliometric analysis. *Thinking Skills and Creativity*, *47*, 101224. https://doi.org/10.1016/j.tsc.2022.101224

Creswell, J. W. (2009). *Research design: Qualitative, quantitative, and mixed methods approaches* (3rd ed.). Sage Publications.

Dagienė, V., Sentance, S., & Stupurienė, G. (2017). Developing a two-dimensional categorization system for educational tasks in informatics. *Informatica, 28*(1), 23–44. https://doi.org/10.15388/Informatica.2017.119

Engelstein, G., & Shalev, I. (2022). Building blocks of tabletop game design: An encyclopedia of mechanisms (2nd ed.). CRC Press. https://doi.org/10.1201/9781003179184

Grover, S., & Pea, R. (2017). Computational thinking: A competency whose time has come. In S. Sentence, E. Barendsen, & C. Schulte (Eds.), *Computer Science Education*, (pp. 19-38). https://doi.org/10.5040/9781350057142.ch-003

Kafai, Y., Proctor, C., & Lui, D. (2020). From theory bias to theory dialogue: Embracing cognitive, situated, and critical framings of computational thinking in K-12 CS Education. *ACM Inroads*, *11*(1), 44–53. https://doi.org/10.1145/3381887

Lee, I., Martin, F., Denner, J., Coulter, B., Allan, W., Erickson, J., Malyn-Smith, J., & Werner, L. (2011). Computational thinking for youth in practice. *Education Inquiry*, *2*(1), 32–37. https://doi.org/10.1145/1929887.1929902

Machuqueiro, F., & Piedade, J. (2022). Development of computational thinking using board games: A systematic literature review based on empirical studies. *Revista Prisma Social, 38*, 5–36. https://revistaprismasocial.es/article/view/4766

Machuqueiro, F., & Piedade, J. (2023). Exploring the potential of modern board games to support computational thinking. *2023 International Symposium on Computers in Education (SIIE)*, Setúbal, Portugal, 2023, (pp. 1-8). https://doi.org/10.1109/SIIE59826.2023.10423693

Machuqueiro, F., & Piedade, J. (2024). Modern board games and computational thinking: Results of a systematic analysis process. *Educational Media International, 61*(1-2), 161–183. https://doi.org/10.1080/09523987.2024.2359762

Menon, D., Romero, M., & Viéville, T. (2019). Computational thinking development and assessment through tabletop escape games. *International Journal of Serious Games*, *6*(4), 3–18. https://doi.org/10.17083/ijsg.v6i4.319

Moreno-León, J., Robles, G., & Román-González, M. (2015). Dr. Scratch: Automatic analysis of scratch projects to assess and foster computational thinking. *Revista de Educación a Distancia*, *46*, 1-23.

Munasinghe, B., Bell, T., & Robins, A. (2023). Unplugged activities as a catalyst when teaching introductory programming. *Journal of Pedagogical Research, 7*(2), 56–71. https://doi.org/10.33902/JPR.202318546

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. BasicBooks.

Papert, S. (1993). *The children's machine: Rethinking school in the age of the computer*. BasicBooks.

Relkin, E., Johnson, S., & Bers, M. (2023). A normative analysis of the TechCheck computational thinking assessment. *Educational Technology & Society, 26*(2), 118-130. https://doi.org/10.30191/ETS.202304_26(2).0009

Shute, V. J., Sun, C., & Asbell-Clarke, J. (2017). Demystifying computational thinking. *Educational Research Review*, *22*, 142–158. https://doi.org/10.1016/j.edurev.2017.09.003

Sinek, S. (2009). *Start with why: How great leaders inspire everyone to take action*. Portfolio.

Somma, R. (2020). *Coding in the classroom: Why you should care about teaching computer science*. No Starch Press.

Sousa, M. (2013). Mastering modern board game dDesign to build new lng experiences: The MBGTOTEACH Framework. *International Journal of Games and Social Impact*, *1*(1), 68–93. https://doi.org/10.24140/ijgsi.v1.n1.04

Tsarava, K., Moeller, K., & Ninaus, M. (2019). Board games for training computational thinking. In M. Gentile, M. Allegra, & H. Söbke, (Eds.), *Games and Learning Alliance. GALA 2018: Lecture Notes in Computer Science, 11385* (pp. 75–85). Springer. https://doi.org/10.1007/978-3-030-11548-7_9

Tseng, C., Doll, J., & Varma, K. (2019). Exploring evidence that board games can support computational thinking. In *Proceedings of International Conference on Computational Thinking Education (pp.* 61–64).

Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, *49*(3), 140–158.

Wing, J. M. (2008). Computational thinking and thinking about computing. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *366*(1881), 3717–3725. https://doi.org/10.1098/rsta.2008.0118

Yang, D., Yang, Z., & Bers, M. U. (2023). The efficacy of a computer science curriculum for early childhood: Evidence from a randomized controlled trial in K-2 classrooms. *Computer Science Education*, *35*(2), 1–21. https://doi.org/10.1080/08993408.2023.2279198

Zapata Cáceres, M., Martín-Barroso, E., & Román-González, M. (2021). BCTt: Beginners Computational Thinking Test. *In Understanding computing education: Vol. 1* (pp.46-56). Proceedings of the Raspberry Pi Foundation Research Seminar Series. rpf.io/seminar-proceedings-vol-1-zapata-caceres-et-al

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