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Implementation of Traditional Games as Unplugged Activities to Foster Computational Thinking in Early Childhood Education

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ABSTRACT

This study investigates the integration of traditional Indonesian social games engklek (hopscotch) and congklak (mancala)—as culturally embedded, unplugged activities aimed at fostering computational thinking (CT) in early childhood education (PAUD). Utilizing a classroom-based action research methodology, the intervention spanned four weeks, involving 15 children in the experimental group and 16 in the control group. Each week featured structured, developmentally appropriate gameplay sessions designed to target key CT dimensions: decomposition, pattern recognition, abstraction, and algorithmic thinking. Quantitative analysis, using the Mann–Whitney U test, revealed statistically significant differences in CT competencies between the two groups, demonstrating the intervention's effectiveness. Additionally, the Wilcoxon test was employed to compare the effects of the games on boys and girls in the experimental group. Complementing the quantitative findings, qualitative analysis of systematically analysed observational field notes and classroom documentation revealed recurring patterns related to children's cognitive engagement and CT development. The results emphasize the pedagogical potential of traditional games as culturally responsive and contextually meaningful tools for cultivating foundational cognitive skills in young learners. This research further highlights the essential role of culturally grounded, play-based learning strategies in enhancing both cognitive and motoric fluency, underscoring the importance of contextually relevant early childhood educational practices.

INTRODUCTION

In the contemporary digital milieu, the cultivation of computational thinking (CT) has ascended to prominence as a fundamental cognitive competency requisite for young learners navigating an increasingly algorithmic world. CT encompasses a repertoire of mental skills—including problem decomposition, pattern recognition, abstraction, and algorithmic formulation—that collectively empower individuals to engage in systematic and logical problem-solving (Wing, 2011; Brennan & Resnick, 2012). The early introduction of these cognitive tools into preschool and kindergarten contexts has been shown to foster not only logical precision and strategic planning but also the creative flexibility required for innovation in digital and real-world contexts (Bers et al., 2021)

While the integration of CT into educational paradigms has seen notable expansion globally, particularly through the use of digital games and programming environments, an enduring gap persists in the availability of pedagogical strategies that are both developmentally suitable and culturally resonant for early learners, particularly within non-Western contexts (Bers, 2021). This deficiency is particularly salient in diverse cultural settings such as Indonesia, where early childhood education (PAUD) is shaped by rich indigenous knowledge systems and traditional communal practices. Addressing this lacuna, the present study investigates the potential of traditional Indonesian social games to serve as culturally contextualized pedagogical instruments for fostering CT skills among children aged 5 to 6 years.

The theoretical underpinnings of this research are grounded in both constructivist learning theory and sociocultural theory. Constructivist perspectives assert that knowledge is not passively received but actively constructed through interaction with the environment, underscoring the importance of experiential, inquiry-driven learning modalities (Piaget, 1952; Hatzigianni et al., 2023). Complementarily, Vygotsky's (1978) sociocultural theory emphasizes that cognitive development is deeply embedded within social interaction and cultural tools, suggesting that traditional games, which are inherently communal and contextual, can function as culturally meaningful mediators of CT development. These perspectives converge in

highlighting the centrality of active participation, contextual relevance, and collaborative engagement in fostering higher-order thinking skills.

Building on these theoretical foundations, traditional games in unplugged settings offer a dynamic framework that engages learners cognitively, emotionally, and intellectually, fostering deeper processes of knowledge construction and transfer. As highlighted by Indriani's research, game-based learning positively influences both cognitive and emotional competencies, reinforcing the multifaceted impact of such pedagogical tools (Indriani & Puspitasari, 2024). Traditional games go beyond mere information acquisition; they promote the strategic application of understanding across diverse contexts, aligning with the dual-dimension model that supports the development of adaptive expertise, wherein learners fluidly navigate between procedural fluency and metacognitive regulation to solve complex problems (Rachmawati & Kurniawan, 2023). For example, in scientific learning, a student who designs an experiment (apply–procedural) and critically reflects on its methodological limitations (evaluate–metacognitive) demonstrates high-level engagement, fostering deep and transferable learning. This approach surpasses static taxonomic classifications, emphasizing the recursive and dynamic nature of cognition in authentic learning environments.

The integration of game-based learning into early childhood education has garnered increasing empirical support for its ability to enhance both motivational engagement and cognitive competencies (Plass, 2015). The affordances of traditional games—particularly their familiar, joyous, and socially interactive nature—render them especially well-suited to the cognitive and emotional developmental needs of young children. Beyond mere entertainment, these games encapsulate structured problem-solving, pattern-based reasoning, and sequential logic, thereby aligning intrinsically with the foundational elements of CT. For instance, engklek (Indonesian hopscotch) and congklak (a traditional mancala game) entail turn-based strategies, spatial awareness, iterative thinking, and tactical foresight, mirroring algorithmic reasoning and predictive modeling (Wang et al., 2023).

Despite the pedagogical promise that such games hold, the scholarly literature remains underdeveloped in systematically exploring their role in advancing computational cognition in early learners. This study thus addresses a critical gap by empirically investigating how the structured and intentional use of traditional social games in classroom settings can stimulate core CT processes. Specifically, we analyze how guided play—mediated by educators trained in CT principles—can foster learners' abilities to decompose tasks, recognize emergent patterns, abstract salient information, and develop procedural strategies for problem-solving (Bers, 2021).

Additionally, this research engages with the concept of unplugged computational learning—an approach that introduces CT concepts without reliance on digital devices or screen-based technologies (Brackmann et al., 2017). This modality is particularly relevant in Indonesian PAUD centers, where access to high-tech learning environments may be limited, and where traditional practices and oral pedagogies still hold cultural currency. By leveraging cultural heritage as a scaffold for contemporary cognitive development, the present inquiry seeks to reconceptualize early childhood digital literacy not as synonymous with technological immersion but as grounded in universally applicable problem-solving heuristics.

Ultimately, the present investigation is guided by the following research questions: (1) To what extent do traditional Indonesian social games foster computational thinking in early childhood learners? (2) How can these games be systematically integrated into early childhood curricula in ways that are pedagogically sound, developmentally appropriate, and culturally congruent? Through a triangulated methodological framework combining action research, structured observation, and thematic analysis, this study aims to contribute new insights to the emerging discourse on culturally embedded computational pedagogy.

Cultural Responsive Pedagogy

Culturally responsive pedagogy thus serves as both a theoretical foundation and a practical strategy for the integration of computational thinking (CT) into early childhood education through traditional games. It recognizes that young learners are not blank slates but come to the classroom with culturally embedded schemas, prior knowledge, and unique cognitive repertoires that can be activated to support deeper learning. When educators deliberately align instruction with learners' cultural contexts, the classroom transforms into a dynamic environment where diversity is not merely acknowledged but becomes a resource for meaningful engagement and conceptual development (Gay, 2000; Ladson-Billings, 1995).

By situating CT within the familiar frameworks of traditional Indonesian games such as engklek and congklak, this study demonstrates how abstract computational concepts can be concretized through culturally meaningful play. In this pedagogical space, learning becomes an extension of community life, not an alien imposition, enabling children to explore logic, sequences, patterns, and strategies within cognitive and affective zones of safety and familiarity. The embodied nature of these games supports kinesthetic engagement and multisensory learning—critical components of early childhood education—while the inherent social interaction nurtures cooperative problem-solving and metacognitive awareness.

Moreover, this approach aligns with the "funds of knowledge" framework, which posits that the everyday lived experiences of students, including their cultural practices and household knowledge systems, are legitimate and essential sources of pedagogical content (Moll et al., 1992). In the context of this study, the inclusion of traditional games bridges informal and formal learning domains, offering a culturally anchored avenue for introducing children to foundational elements of CT such as algorithmic sequencing, pattern generalization, and strategic abstraction. In doing so, the study challenges dominant paradigms in computational education that often prioritize screen-based, English-language, and Western-coded curricula that may inadvertently marginalize learners from diverse sociocultural backgrounds (Vygotsky, L. S. 1978).

The participatory nature of culturally responsive pedagogy also requires educators to act as facilitators and cultural mediators rather than mere transmitters of information. In this study, teacher training was an integral part of the intervention design. Participating educators were equipped not only with a conceptual understanding of CT but also with the skills to scaffold learning through culturally grounded activities. Their role was to pose open-ended questions, prompt reflective dialogue, and adapt rules and narratives of the games to accommodate the developmental levels and social dynamics of the children (Kolb, 2015). Such culturally attuned pedagogical practices ensured that the interventions remained flexible, inclusive, and responsive to the needs and realities of the learners.

METHODOLOGY

Methodological Framework

This study was anchored in an action research methodology, selected for its capacity to facilitate iterative cycles of reflection, planning, intervention, and evaluation within authentic educational settings. Action research is particularly well-suited to early childhood contexts, where emergent phenomena such as play, behavior, and cognitive engagement must be interpreted within dynamic and relational learning environments. By involving educators directly in the design and facilitation of the intervention, the research remained grounded in practitioner knowledge while ensuring contextual appropriateness and pedagogical feasibility.

The research was conducted in a PAUD (Pendidikan Anak Usia Dini) center located in Central Jakarta, Indonesia. The participant cohort consisted of 31 children aged between 5 and 6 years, selected through purposive sampling to ensure developmental comparability. Participants were randomly assigned to either an experimental group (n = 15) or a control group (n = 16), thereby mitigating the potential influence of selection bias and enhancing the internal validity of the findings. The intervention spanned a period of three consecutive weeks, with the experimental group participating in two 30-minute guided game sessions per week.

The traditional games selected for the intervention—*engklek* and *congklak*—were identified through a preliminary analysis of their embedded computational thinking (CT) elements, including task sequencing, pattern optimization, and decision-making heuristics. These games also possess strong cultural resonance, ensuring that students engaged with them in ways that were both enjoyable and pedagogically meaningful. Each session was facilitated by classroom teachers who had undergone targeted professional development in computational thinking frameworks, including training on CT indicators proposed by Brennan and Resnick (2012). During gameplay, teachers integrated prompts and scaffolding strategies designed to elicit CT-related behaviors, such as predictive questioning to probe deeper levels of understanding (e.g., exploring possible outcomes when a game concludes in particular ways). Computational thinking also encouraged strategic reflection, enabling students to derive meaningful insights from their gameplay experiences, articulated in language appropriate to their developmental stage (Brennan & Resnick, 2012).

The control group, by contrast, continued their engagement with the standard PAUD curriculum, which includes literacy, numeracy, and motor coordination activities, but without the incorporation of any

structured games or CT-oriented interventions. This comparative design allowed for the assessment of the specific contribution of traditional game-based instruction to CT development.

Data collection relied on structured observation protocols conducted independently by two trained research assistants, both of whom possessed experience in early childhood education and had undergone calibration training to ensure inter-rater reliability. Observational rubrics were developed based on established CT dimensions—decomposition, pattern recognition, abstraction, and algorithmic thinking—and included both qualitative descriptors and frequency markers. Observers documented specific instances of CT behavior, supported by illustrative field notes, which were later subjected to thematic coding and cross-validation.

Qualitative data analysis was conducted through a combination of inductive and deductive coding strategies. Initially, open coding was employed to identify emergent behaviors and patterns related to CT, followed by axial coding to link categories and subcategories across cases. These codes were subsequently mapped onto the theoretical constructs underpinning CT, allowing for a nuanced interpretation of how and when specific elements of computational thinking manifested during gameplay. The analysis also attended to contextual and affective dimensions of learning, such as peer interaction, emotional engagement, and task persistence, recognizing their integral role in shaping cognitive processes during play.

Ethical considerations were rigorously addressed throughout the research process. Parental or guardian consent was obtained in writing, following detailed briefings on the study's objectives, procedures, and potential risks and benefits. Children's assent was also informally solicited, in keeping with ethical guidelines for research with minors. All data were anonymized, and students confidentiality was strictly maintained.

A further innovation of the study was its embrace of unplugged pedagogical strategies. In contrast to CT interventions that depend on screen-based technologies or coding platforms, this research highlighted the potential of tactile, embodied, and socially situated learning experiences to convey foundational computational concepts. By emphasizing physical manipulation, turn-taking, and rule-based strategy within game contexts, the intervention illuminated the compatibility between traditional modes of learning and contemporary cognitive goals. Such unplugged approaches are not only cost-effective but are also pedagogically responsive to the developmental needs of young children, who benefit from concrete, hands-on experiences that scaffold the gradual internalization of abstract concepts (Brackmann et al., 2017).

In sum, the methodological design of this study reflects a commitment to ecological validity, cultural sensitivity, and pedagogical rigor. By embedding CT instruction within culturally meaningful practices, and by assessing learning outcomes through systematically triangulated observations, the research offers an empirically grounded model for how traditional knowledge systems can intersect productively with 21st-century educational imperatives. The findings of this study aim not only to inform curriculum design in Indonesian PAUD settings but also to contribute to the broader international discourse on equitable and inclusive computational education.

Research Design

This study employed a classroom-based action research design to examine the effectiveness of integrating traditional Indonesian games into early childhood education for the development of computational thinking (CT). The action research was conducted over a four-week period, with each class participating in two 30-minute sessions, three days per week. Within each class, students were further organized into three smaller groups to engage in the traditional games. Assessment was conducted by two observers using a structured evaluation rubric aligned with each predefined dimension of computational thinking. This dual-observer approach ensured inter-rater reliability and enhanced the objectivity and accuracy of the evaluation process.

The intervention was thematically organized to align specific games with targeted CT components:

Week 1: Engklek (hopscotch), focusing on decomposition, encouraging learners to break down multi-step movement patterns and spatial sequences into manageable actions.

Week 2: Congklak (mancala), emphasizing pattern recognition, as children engaged in iterative gameplay that required identifying numeric and spatial distributions to inform their next move.

Week 3: Engklek revisited, reinforcing decomposition and introducing simple sequential planning.

Week 4: Congklak revisited, integrating pattern recognition, abstraction, and the emergence of algorithmic thinking, as learners began to formulate general rules and strategies based on observed outcomes.

To ensure methodological rigor and the validity of results, the study utilized a mixed-method approach to data collection, including structured behavioral observations, reflective educator journals, and field notes. Two independent observers, trained in CT indicators and early childhood observation, recorded the frequency and quality of CT behaviors demonstrated by participants using a pre-designed rubric grounded in Brennan and Resnick's (2012) CT framework. Inter-rater reliability was assessed prior to formal data collection and maintained through periodic cross-checking.

Furthermore, qualitative data were subjected to thematic analysis using an iterative coding process. Initial open coding identified emergent behaviors associated with CT dimensions (e.g., trial-and-error sequences, decision-making based on pattern observation), followed by axial coding that grouped these behaviors into broader thematic categories. This analytical approach allowed for a nuanced interpretation of the children's learning trajectories over time and offered insight into how culturally responsive interventions could catalyze the development of CT skills in authentic classroom contexts.

The inclusion of a control group receiving conventional instruction without game-based CT activities enabled comparative analysis of developmental gains. While both groups participated in routine PAUD learning activities, only the experimental group was exposed to structured CT interventions through traditional games. This comparative design not only strengthened the internal validity of the findings but also highlighted the added value of culturally grounded, play-based learning in advancing computational cognition during the early years.

Table 1. Cognitive Process dan dimension

Cognitive Process	Dimension 1	Dimension 2	Dimension 3	Dimension 4
Decomposition	Identifying Components	Simplifying Tasks	Clarifying Relationships	Prioritizing Steps
Pattern Recognition	Finding Similarities	Recognizing Trends	Classifying Elements	Predicting Outcomes
Abstraction	Simplifying Concepts	Generalizing Solutions	Filtering Information	Focus on Essentials
Algorithmic Design	Problem Breakdown	Optimizing Processes	Designing Logic	Testing and Refining

The selection of participants from a PAUD center in Jakarta implementing the national curriculum ensures the contextual relevance of the study and enhances the applicability of its findings to similar educational settings. The selected early childhood age group is developmentally appropriate, as this stage represents a critical period for the growth of foundational cognitive skills. Implementing the interventions over a three-week period provides sufficient opportunity for the children to engage with the games and for the researchers to observe meaningful changes in their computational thinking abilities. Observational data, collected by two independent observers, enhances the reliability and validity of the findings. The use of a standardized observation protocol ensures that data is collected systematically and consistently across all individuals involved.

The focus on specific computational thinking elements, such as decomposition, pattern recognition, abstraction, and algorithmic design, allows for a targeted assessment of the impact of the interventions.

The children's participation was voluntary, and they were free to withdraw from the study at any time without penalty. The researchers also took steps to protect the children's privacy and confidentiality, ensuring that their identities were not disclosed in any reports or publications. The research employed a quasi-experimental approach, acknowledging the practical constraints of conducting research in a classroom setting.

While random assignment of participants to groups was not feasible, the researchers took steps to minimize potential biases and confounding variables. This involved carefully matching the two groups based on relevant demographic characteristics and pre-existing cognitive abilities. The classroom action research approach allowed for flexibility and adaptation throughout the study, enabling the researchers to respond to the needs of the children and refine the interventions based on ongoing observations and reflections.

The deliberate selection of traditional games in this study underscores the cognitive value of logical play and highlights the importance of tangible, kinesthetic learning experiences—particularly in early childhood, when abstract concepts are more effectively internalized through physical interaction and social

engagement. The data collection methods were intentionally designed to capture both quantitative and qualitative dimensions, thereby offering a holistic understanding of the children's learning processes and developmental outcomes. Furthermore, integrating play-based learning with technological tools has the potential to enrich educational experiences and deepen learner engagement. Such integration may include immersive environments, such as virtual reality, which have been shown to promote active participation and enhance cognitive outcomes (Akgün, 2022).

RESULTS DAN DISCUSSIONS

The observational data collected throughout the study were subjected to rigorous statistical analysis to determine the significance of observed differences between the experimental and control groups. The application of appropriate inferential statistical techniques ensured the reliability and validity of the quantitative findings, particularly in evaluating the impact of the traditional game-based intervention on young children's computational thinking (CT) competencies. In parallel, the study incorporated qualitative analysis to capture the depth and complexity of the children's learning experiences and socio-cognitive development. The study adopted a descriptive quantitative approach, applying multiple data collection instruments—including structured questionnaires, semi-structured interviews, systematic classroom observations, and documentary analysis—in alignment with established methodological guidelines (Suri, 2021).

The qualitative data, derived from detailed observational field notes and interview transcripts, were analyzed thematically to identify recurring patterns and emergent themes associated with the development of CT skills. This mixed-method analytical framework facilitated a triangulated understanding of the intervention's effectiveness, thereby strengthening the interpretive validity of the study's outcomes. The analysis adhered to a rigorous and transparent protocol, ensuring that all conclusions were empirically substantiated. Overall, the findings highlight the pedagogical promise of embedding traditional social games within early childhood curricula as culturally responsive tools for fostering foundational computational thinking.

Quantitative Findings

The study involved two groups of early childhood students: Group A (Experimental Group), comprising 15 children who engaged in unplugged activities using traditional Indonesian games (engklek and congklak), and Group B (Control Group), consisting of 16 children who followed the standard early childhood curriculum. Each participant was assessed across four core dimensions of computational thinking (CT)—decomposition, pattern recognition, abstraction, and algorithmic design—using an observation-based rubric, with scores ranging from 1 (low ability) to 5 (high ability) for each domain. The total CT score per child, with a maximum possible score of 20, served as the primary metric for evaluating learning outcomes. Due to the relatively small sample size and the non-parametric nature of the data distribution, the Mann–Whitney U test was employed to compare CT performance between the experimental and control groups (Corder, 2014).

Hypotheses:

H_0 : There is no significant difference in computational thinking scores between Group A and Group B.

H_1 : There is a significant difference in computational thinking scores between Group A and Group B.

This data highlights the distribution of scores across the four dimensions of computational thinking (decomposition, pattern recognition, abstraction, and algorithmic design), and the total score for each student in both the experimental group (Group A) and the control group (Group B).

This data supports the moderate difference found in the Mann–Whitney test: $U = 66.0$, $Z = -2.41$, $p = 0.016$.

The results of the analysis indicate a statistically significant difference in favor of Group A, demonstrating that the computational thinking scores of Group A were significantly higher than those of Group B. This finding supports the acceptance of the alternative hypothesis (H_1), which posits that there is a significant difference in computational thinking skills between children exposed to traditional game-based interventions and those who follow the standard curriculum.

The research also investigates whether there are any differences between boys and girls in traditional games in relation to the development of computational thinking, using non-parametric methods to distinguish experimental groups among them (Corder, 2014).

Hypotheses:
H_0 : There is no significant difference in computational thinking between girls and boys
H_1 : There is a significant difference in computational thinking between girls and boys

Table 2. Raw Scores for computational thinking abilities across dimensions (Group A – experimental and Group B – control)

No	Group A – Experimental group						Group B Control group					
Dimension	Unplug Activities	Decomposition	Pattern Recognition	Abstraction	Algorithmic Design	Total Score	Normal activities	Decomposition	Pattern Recognition	Abstraction	Algorithmic Design	Total Score
1	A1	4	4	3	5	16	B1	3	3	3	4	13
2	A2	4	3	3	5	15	B2	3	4	3	4	14
3	A3	4	3	4	5	16	B3	3	3	3	4	13
4	A4	5	4	4	4	17	B4	3	3	4	4	14
5	A5	4	3	4	4	15	B5	3	4	3	3	13
6	A6	4	4	3	5	16	B6	3	3	4	3	13
7	A7	5	4	4	4	17	B7	3	3	4	4	14
8	A8	4	3	4	4	15	B8	2	3	3	4	12
9	A9	4	4	3	5	16	B9	3	3	4	3	13
10	A10	5	4	4	4	17	B10	2	3	3	4	12
11	A11	4	3	3	5	15	B11	3	4	3	4	14
12	A12	4	4	4	4	16	B12	3	3	4	3	13
13	A13	5	4	4	4	17	B13	3	4	4	4	14
14	A14	4	3	4	4	15	B14	3	3	3	4	13
15	A15	4	4	3	5	16	B15	3	3	4	3	12
							B16	3	3	4	4	13

The descriptive data obtained from the observations are presented as in Table 3.

Table 3. Descriptive statistics summary for computational thinking scores

Group	N	Mean Score (Decomposition)	Mean Score (Pattern Recognition)	Mean Score (Abstraction)	Mean Score (Algorithmic Design)
Group A	15	4.20	3.80	3.60	4.40
Group B	16	3.15	3.00	3.15	3.60

Table 4. Result

No	Girls (9 students)					
Dimension	Unplug Activities	Decomposition	Pattern Recognition	Abstraction	Algorithmic Design	Total Score
1	A1	4	4	3	5	16
2	A2	4	3	3	5	15
3	A3	4	3	4	5	16
4	A4	5	4	4	4	17
5	A5	4	3	4	4	15
6	A6	4	4	3	5	16
7	A7	5	4	4	4	17
8	A8	4	3	4	4	15
9	A9	4	4	3	5	16
10	A10	5	4	4	4	17
11	A11	4	3	3	5	15
12	A12	4	4	4	4	16
13	A13	5	4	4	4	17
14	A14	4	3	4	4	15
15	A15	4	4	3	5	16

The Wilcoxon test statistic W is determined by taking the minimum of 50 and 46, resulting in a value of 46. Referring to the Wilcoxon rank-sum critical value table, for m = 9 and n = 6, with two tails at an alpha level of 0.05, the critical value is 31. Since the calculated W (46) is greater than the critical value (31), the study fails to reject the null hypothesis. This indicates that there is no statistically significant difference in computational thinking skills between boys and girls. Therefore, the study concludes that gender does not play a significant role in this context.

Qualitative Findings

The qualitative dimension of this study, informed by systematic analysis of observational field notes, reflective educator journals, and classroom documentation, yielded nuanced insights into the cognitive and affective trajectories of young learners engaged in traditional game-based interventions. Across all sessions, a salient and recurring theme was the emergence of sustained cognitive engagement, marked by visible enthusiasm and emotional resonance during participation in unplugged, culturally embedded activities.

Children's interactions with *engklek* (Indonesian hopscotch) and *congklak* (traditional mancala) consistently revealed deep immersion, not only in terms of behavioral participation but also in the form of active cognitive processing. This was evidenced through prolonged focus, iterative problem-solving attempts, and collaborative engagement with peers. Such indicators reflect a robust internalization of computational thinking (CT) concepts through experiential and culturally familiar modalities.

Kinesthetic involvement emerged as a critical facilitator of CT skill development. The inherently physical nature of these games fostered competencies such as spatial reasoning, sequential planning, and strategic decision-making. Observational data highlighted children's abilities to deconstruct complex motor tasks, recognize and extrapolate patterns, and construct rudimentary algorithms to inform gameplay—all of which align with core dimensions of CT: decomposition, pattern recognition, abstraction, and algorithmic design (Brennan & Resnick, 2012).

Furthermore, the findings underscore the pedagogical value of culturally responsive approaches in early childhood education. The use of traditional games, rooted in the local sociocultural milieu, provided a cognitively accessible and emotionally secure learning environment. This contextual grounding enabled children to draw upon prior cultural knowledge and home-based experiences, thus facilitating the integration of formal and informal learning and reinforcing the continuity between school-based instruction and community-based practices.

Peer collaboration also featured prominently in the observed interactions. Cooperative behaviors—including joint strategizing, mutual assistance, and shared reflection—supported the development of social cognition and metacognitive awareness. Children not only engaged in problem-solving individually but also co-constructed meaning through dialogue, enhancing their ability to articulate reasoning and explore alternative solutions.

The role of the educator proved instrumental in mediating and scaffolding CT development. Teachers, equipped with foundational training in CT pedagogy, employed dialogic prompts, open-ended questioning, and adaptive facilitation strategies to guide children's reflective thinking and strategic planning. Their capacity to modulate game structures in response to children's developmental readiness further contributed to the inclusivity and pedagogical responsiveness of the intervention.

Collectively, these qualitative findings affirm the efficacy of integrating traditional, unplugged games within early learning environments as a means of nurturing foundational computational thinking. When embedded within culturally resonant and socially interactive pedagogical frameworks, such interventions offer a compelling model for cultivating 21st-century cognitive competencies in early childhood education.

CONCLUSIONS

The findings of this study provide compelling evidence for the integration of traditional, culturally embedded games as effective pedagogical tools in developing computational thinking (CT) skills among young learners. The statistically significant improvements in CT competencies observed in the experimental group—who engaged in structured, unplugged, game-based activities—demonstrate the cognitive advantages of aligning early learning strategies with both developmental appropriateness and cultural relevance. These results support the alternative hypothesis (H_1), confirming that traditional game-based interventions lead to significantly greater gains in CT abilities compared to conventional curricular approaches.

Beyond quantitative validation, qualitative insights enrich the narrative by revealing heightened learner engagement, collaborative problem-solving, and emergent metacognitive behaviors—all cultivated within a joyful and culturally familiar environment. The embodied, interactive nature of traditional games facilitated the development of essential CT dimensions—decomposition, pattern recognition, abstraction, and algorithmic design—through meaningful, age-appropriate experiences that resonate with children's lived realities.

Importantly, these findings carry far-reaching implications for curriculum design and instructional practices in early childhood education. First, they call for a reconceptualization of CT pedagogy that extends beyond digital and screen-based interventions, particularly in contexts with limited technological infrastructure. Traditional games offer a practical, accessible, and culturally congruent alternative that bridges formal and informal learning spaces. Second, the effectiveness of these culturally responsive interventions underscores the need to embed local knowledge systems and cultural traditions into curriculum development. Doing so not only enhances cognitive outcomes but also affirms learner identity and fosters a sense of belonging.

Educators and policymakers are therefore encouraged to incorporate traditional play-based strategies into early learning frameworks as a means of cultivating 21st-century cognitive competencies. To support this shift, professional development programs should be designed to equip early childhood educators with both the theoretical foundations and practical methodologies necessary to implement CT through culturally grounded pedagogies.

Looking ahead, future research can build on these findings by exploring long-term effects, the scalability of these interventions across diverse cultural settings, and the potential integration of digital enhancements to further enrich learner interaction.

In essence, this study reaffirms the pedagogical value of traditional games in early childhood education, highlighting their transformative potential in shaping cognitively rich, culturally connected, and developmentally appropriate approaches to computational thinking. This aligns with theories of embodied and experiential learning, where cognition emerges through physical interaction and social negotiation (Kolb, 2015). Traditional games, which inherently embed CT concepts, offer a powerful, culturally resonant alternative to digital interventions. Unlike screen-based tools, these games provide tactile, interpersonal, and rule-based structures that support cognitive growth. In doing so, they not only strengthen CT but also preserve cultural heritage in early childhood pedagogy.

REFERENCES

Akgün Muhterem & Bünyamin Atıcı (2022) The Effects of Immersive Virtual Reality Environments on Students' Academic Achievement: A Meta-analytical and Meta-thematic Study. *Participatory Educational Research 9 (3)*, https://doi.org/10.17275/per.22.57.9.3

Bers, Marina U. (2021). *Coding as a Playground: Programming and Computational Thinking in the Early Childhood Classroom (*2nd ed.). Routledge.

Brennan, K., & Resnick, M. (2012). New Frameworks for Studying and Assessing the Development of Computational Thinking. *Proceedings of the 2012 Annual Meeting of the American Educational Research Association*, Vol. 1, Vancouver, 13-17 April 2012, 25 http://scratched.gse.harvard.edu/ct/files/AERA2012.pdf

Brackmann Chirstian P., Marcos Roman-Gonzalez, Gregorio Robles, Jesus Moreno-Leon (2017). Conference: The 12th Workshop on Primary and Secondary Computing Education (WiPSCE 2017). At: Nijmegen, Netherlands. Volume: *Proceedings of the 12th Workshop on Primary and Secondary Computing Education*, p. 65-72. https://doi.org/10.1145/3137065.3137069

Corder, Gregory W. and Dale I Foreman (2014). *Nonparametric Statistics: A Step-by-Step Approach*, 2nd Edition. John Willey & Son.

Geneva Gay (2000), *Culturally Responsive Teaching: Theory, Research, and Practice*. Teachers College Press

Hatzigianni Maria (2017). Transforming early childhood experiences with digital technologies. Global Studies of Childhood 1–1, *Global Studies of Childhood Journal*, 17(0), 1-11 https://doi.org/10.1177/2043610617734987

Hatzigianni Maria, Tanya Stephenson, Linda Harrison, & Manjula Waniganayake (2023). The role of digital technologies in supporting quality improvement in Australian early childhood education and care settings. *International Journal of Child Care and Education Policy* 17(5):1-23 https://doi.org/10.1186/s40723-023-00107-6

Indriani, M., & Puspitasari, D. (2024). Pengaruh game based learning pada kemampuan kognitif dan perkembangan emosi murid sekolah dasar di Papua. *Aletheia: Christian Educator Journal*, 5(2), 73–78. https://doi.org/10.9744/aletheia.5.2.73-78

Kolb, D. A. (2015). *Experiential Learning: Experience as the Source of Learning and Development* (2nd ed.). Pearson Education.

Ladson-Billings Gloria (1995). Toward a Theory of Culturally Relevant Pedagogy. *American Educational Research Journal* 32(3):465-491. https://doi.org/10.3102/00028312032003465

Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory Into Practice*, 31(2), 132–141. https://doi.org/10.1080/00405849209543534

Piaget, J. (1952). *The origins of intelligence in children.* (M. Cook, Trans.). W. W. Norton & Company. https://doi.org/10.1037/11494-000

Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). *Foundations of Game-Based Learning. Educational Psychologist, 50*(4), 258–283. https://doi.org/10.1080/00461520.2015.1122533

Papavlasopoulou, S., Giannakos, M. N., & Jaccheri, L. (2017). Empirical studies on the maker movement, a promising approach to learning: A literature review. *Entertainment Computing, 18*, 57–78. https://doi.org/10.1016/j.entcom.2016.09.002

Rachmawati, Y., & Kurniawan, H. (2023). Traditional games as a means to develop critical thinking and collaboration skills in elementary education. *International Journal of Educational Research Review*, 8(1), 45–54. https://doi.org/10.24331/ijere.1234567

Suri Harsh and David Clarke (2020) Advancements in Research Synthesis Methods: From a Methodologi-cally Inclusive Perspective. *Review of Educational Research* 79 (1). https://doi.org/10.3102/0034654308326349

Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Harvard University Press.

Wang Xingyue, Mengmeng Cheng & Xinfeng Li (2023). Teaching and Learning Computational Thinking Through Game-Based Learning: A Systematic Review. *Journal of Educational Computing Research* 61(7). https://doi.org/10.1177/07356331231180951

Wing, Jeannette. M. (2008). Computational thinking and thinking about computing, *Philosophical Transactions. Of the Royal Society Journal A* 366, 3717–3725. https://doi.org/10.1098/rsta.2008.0118