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The Impact Of STEAM-Based Unplugged Activities In Influencing Early Childhood Computational Thinking

Sunimaryanti [1]✉
[1]Early Childhood Education Teacher Education, STITNU Sakinah Dharmasraya,Indonesia

ABSTRACT
This study investigates how STEAM-based unplugged activities can foster computational thinking skills among early childhood learners at Angkasa Lanud Adisucipto Yogyakarta Kindergarten. Children aged 5–6 years from group B were selected using purposive sampling. Data were collected through interviews, observations, and documentation, and validated using triangulation techniques to ensure credibility. To maintain methodological consistency, the study operationalizes computational thinking through three empirically observable indicators: pattern recognition, sequencing, and problem solving & debugging. The findings reveal that these indicators emerge across three primary forms of unplugged activities. First, Lego construction tasks engage children in identifying structural patterns, arranging blocks in sequential steps, and correcting placement errors. Second, art-based activities—such as creating simple origami windmills require children to follow systematic folding sequences while refining mistakes to achieve the expected form. Third, angklung musical activities enable children to recognize rhythmic patterns, respond to instructional cues in sequence, and adjust their actions when timing errors occur. These results demonstrate that computational thinking can be meaningfully embedded in early childhood education through developmentally appropriate, non-digital STEAM activities. The study contributes theoretically by clarifying a more grounded set of indicators aligned with early childhood learning processes, and practically by offering evidence that unplugged approaches effectively strengthen foundational problem-solving and procedural reasoning skills.

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Contact Corresponding: Sunimaryanti
Email:ghazalisuni@gmail.com

1. Introduction

Computational thinking (CT) is increasingly recognized as a foundational skill that must be introduced from early childhood. Several countries have integrated CT into their national curricula to strengthen children's problem-solving abilities using systematic and logical processes similar to how computers operate (Bers, 2018; Bers et al., 2019). Importantly, CT can be nurtured without relying on digital technology. Unplugged activities—defined as non-digital, concrete, and often traditional tasks—allow young children to develop CT skills through hands-on routines and everyday experiences (Roman-Gonzalez et al., 2016; Cansu & Cansu, 2019). This makes unplugged methods developmentally appropriate and accessible for preschool learners. Recent literature shows that unplugged activities may include sorting tasks, puzzles, sensory-rich experiences, and simple construction activities (Masarwa et al., 2024). Brackmann et al., (2017) These activities allow children to practice sequencing, pattern recognition, and problem-solving—core elements of computational thinking. However, emerging studies also highlight the relevance of integrating STEAM (Science, Technology, Engineering, Arts, Mathematics) to strengthen learning experiences through interdisciplinary and creative processes. The STEAM framework emphasizes real-world problem-solving by combining scientific reasoning, engineering processes, artistic expression, and mathematical logic (Taibo & Liang, 2022). This opinion is reinforced by V. R. Lee & Recker (2018) which describes unplugged activities in the form of puzzles, stories that are rich in challenges, experiences that are rich in sensory experiences, the cost of carrying out activities is relatively low and the activities carried out are easily accessible to educators and students.

Although the evolution from STEM to STEAM has been discussed extensively, most literature focuses on conceptual debates or historical developments (Anabousy & Daher, 2022; Cheng et al., 2022). Such explanations, however, often overshadow empirical insights on how STEAM can be operationalized specifically for early childhood education. More importantly, previous studies have tended to examine CT either through digital programming tools or through general unplugged methods, yet little is known about how STEAM-based unplugged activities are implemented in preschool settings, especially in the Indonesian context. This creates a clear research gap:

The development of STEAM initially had 2 different opinions at the beginning of its emergence. The first opinion says that initially STEAM developed in the 1880s in the United States, where it was a term for five disciplines that were combined into one, namely science, technology, engineering, art and mathematics. The core concept is to emphasize deep integration between disciplines and has undergone a development process from STS (Science, Technology and Society), SMET (Science, Mathematics, Engineering and Technology) and STEM (Science, Mathematics, Engineering and Technology) which later became STEAM (Taibo & Liang, 2022). Meanwhile, the second opinion says that STEM was first developed by Collwell in the early 1990s, who also came from the United States (Anabousy & Daher, 2022).

To overcome this problem in 2006, experts finally agreed to integrate the concept of art as a new discipline in the context of STEM by conducting theoretical practices such as value evaluation by providing examples (Hsu et al., (2022) found that STEM focused on engineering and the arts is a form of creative design thinking that is very important. Therefore, several studies advocate the expansion of the combination of artistic and humanistic concepts in the STEM concept. Until then it was uniformly adopted and renamed to STEAM (Cheng et al., 2022).

Acting as an interdisciplinary approach in five integrated clusters into one, STEAM is a reference for learning where academic concepts of science, technology, engineering, arts and mathematics are applied in real-world contexts that produce connections between schools, communities, jobs and globally (Rodríguez-Nieto & Alsina, 2022). This discipline allows for holistically integrated cross-curricular study. For example, in science, technology and engineering provide techniques and tools to build objects and solve problems, while in mathematics provides a way for someone to express and present a problem that allows it to be interpreted in simple language so that it can be accepted clearly by society and the environment. In addition, mathematics teaches students to have the ability to think logically and critically in solving a problem. In addition, utilizing art in simple forms can add scientific instrumental weight to technological development by creating needs based on consumer demand through marketing and making advertisements for a product or by dramatizing the appearance of a product to increase its appeal in the eyes of the public (Burnard et al., 2022).

Computational thinking has recently become a spotlight in the world of education. The advancement of information technology science has grown rapidly in terms of theory, technology, systems and tools. Even this influence has penetrated into various fields and domains that provide great comfort for students. Therefore, it is recommended that all students learn computational thinking skills so that they are able to adapt to the era of technology (Hsu et al., 2022). The idea of this skill was first introduced by Seymour Papert (1980), who defined it as procedural thinking and programming. Several years later, the explanation of computational thinking was further interpreted as one of the most important skills in problem solving that can be learned by everyone, not just computer scientists (Su & Yang, 2023). Speculations like this ultimately give rise to many paradigms that whatever field a person is engaged in, computational thinking is considered a very necessary competency.

Then in 2006, Jeanette Wing introduced the term computational thinking as a universal skill set that allows anyone to use computer science concepts for problem solving in the scientific/educational field (Hussain et al., 2022). Then the definition framework for computational thinking is further explained by Brennan and Resnick (2012) who categorize this skill into three dimensions, namely; concept, practice and perspective (Tengler et al., 2021). Computational thinking refers to the ability to understand how information is processed and operated using systematic and logical ways to think and solve problems. There are four main steps of computational thinking, namely; a) decomposition; b) recognition; c) abstraction and d) algorithm. These four phases are used to analyze and solve problems. With the development of science and technology that is always progressing, the understanding and emphasis on computational thinking is gradually promoted.

Opinions regarding the definition of computational thinking were also expressed by Su & Yang (2023) which says that in the world of education this skill refers to the process that allows students to formulate problems and identify solutions presented in a form that can be done by students as information processing and programming agents. Through the interactions that occur, students can consider steps and use skills technically to manipulate problems in solving problems. So that in the 21st century computational thinking is one of the skills that affects a person's life in the future including early childhood. In addition, computational thinking can also be defined as a series involved in formulating problems and finding solutions so that computers (humans or machines) can solve them effectively and are more connected to conceptualization than coding itself (Barradas et al., 2020). To address this gap, this study investigates the implementation of STEAM-based unplugged activities in Angkasa Lanud Adisucipto Yogyakarta Kindergarten to support computational thinking development in children aged 5–6 years.

2. Method

This study employed a descriptive qualitative design using a case study approach at Angkasa Lanud Adisucipto Yogyakarta Kindergarten. The sample consisted of 18 children in group B selected through purposive sampling. Data were collected through observations, interviews, and documentation conducted during classroom activities.

Data analysis followed Miles and Huberman's interactive model, which includes **data reduction, data display, and conclusion drawing**. The analysis process began with **open coding,** where raw field notes and transcripts were segmented into meaningful units. These codes were then **categorized** into broader themes related to STEAM-based unplugged activities and computational thinking indicators. During the interpretation stage, the emerging categories were compared across data sources to identify patterns and ensure analytical consistency. Triangulation of methods (observation, interviews, documentation) strengthened the credibility of the findings.

Ethical considerations were carefully addressed throughout the research process. Informed consent was obtained from the children's parents, and approval was secured from the school. All participants' identities were anonymized to ensure confidentiality. The study adhered to child protection principles by ensuring that all activities posed no physical or emotional risk to the children.

Computational thinking development was assessed using **operationalized indicators** adapted from established CT frameworks, which include: (1) **decomposition**—the child's ability to break tasks into smaller steps; (2) **pattern recognition**—the ability to identify repeated forms or sequences; (3) **abstraction**—the ability to focus on essential features of a task; and (4) **algorithmic thinking**—the ability to follow or create step-by-step procedures. These indicators guided the observation protocol and were used to analyze how children demonstrated CT skills during each STEAM-based unplugged activity. Data collection took place over five consecutive days during learning sessions.

Table 1. Operational Indicators of Early Childhood Computational Thinking

Computational Thinking Component	Operational Indicators (Early Childhood Level)	Examples of Observable Behaviors
Decomposition	The child is able to break down a task into smaller, manageable steps.	• Following sequential steps when creating an origami windmill. • Separating Lego pieces before assembling them.
Pattern Recognition	The child identifies repeated forms, sequences, colors, or rhythms.	• Sorting Lego pieces based on color or shape. • Recognizing rhythmic patterns when playing the angklung according to the teacher's cues.
Abstraction	The child focuses on essential features while ignoring irrelevant details.	• Simplifying shapes during art activities such as origami. • Understanding the main concept of a task without needing unnecessary details.
Algorithmic Thinking	The child follows or creates step-by-step procedures to solve a task.	• Following step-by-step instructions during Lego construction. • Knowing when to start and stop sounding the angklung based on signals.

The indicators used in the analysis were adapted from the four core components of computational thinking (decomposition, pattern recognition, abstraction, and algorithmic thinking). In classroom observation, these components were operationalized into observable behaviors including sequencing, pattern recognition, and problem solving & debugging.

3. *Result And Discussion*

a) Analytical Framework for Early Childhood Computational Thinking

To ensure analytical depth and address the need for a structured framework, this study employed three core indicators of Computational Thinking (CT) abilities in early childhood: **sequencing**, **pattern recognition**, and problem solving with debugging. These indicators were adapted from widely referenced CT frameworks for young learners and aligned with developmentally appropriate practices. Each indicator represents a distinct cognitive process but remains interconnected within the broader domain of CT.

Sequencing refers to the ability of children to organize actions in logical order. At the early childhood level, sequencing is observable through tasks such as arranging picture cards, planning steps for building structures, or following multi-step instructions during hands-on activities. This skill forms the foundation of algorithmic thinking.

Pattern recognition involves identifying and extending recurring relationships among objects, colors, shapes, or movements. For young children, recognizing patterns strengthens their ability to generalize concepts and transfer knowledge across contexts, which is an essential precursor to abstraction in CT.

Problem solving and debugging encompass children's abilities to confront challenges, attempt solutions, notice errors, and make corrections independently. In unplugged contexts, this is commonly observed when children engage in building challenges, experiment-based STEAM tasks, or structured play that requires trial-and-error strategies.

The STEAM-based unplugged intervention designed for this study integrated **Science**, Technology (as processes, not devices), Engineering, Arts, and Mathematics through hands-on, manipulative, and inquiry-driven activities. Examples include building towers with blocks, experimenting with water flow, arranging colored beads in patterns, or role-playing simple engineering tasks. The focus was not on digital tools but on cognitive processes that parallel computational thinking.

This analytical framework guided the coding process during the qualitative data analysis and supported the interpretation of changes in children's CT development throughout the intervention period.

The intervention resulted in notable progress across all three CT indicators. Table 1 presents a synthesized comparison of children's CT performance before and after involvement in STEAM-based unplugged activities.

Table 1. Summary of Children's Computational Thinking Before and After the Intervention

CT Indicator	Before STEAM-Unplugged Intervention	After STEAM-Unplugged Intervention	Observed Change
Sequencing	Children arranged steps inconsistently, often requiring adult guidance	Most children could produce 3–5 sequential steps independently	Increased ability to plan and execute ordered actions
Pattern Recognition	Children recognized simple patterns but struggled to extend or generalize them	Children identified and created more complex patterns using colors, shapes, and objects across STEAM tasks	Strengthened generalization and transfer of patterns
Problem Solving & Debugging	Children tended to wait for adult intervention when facing difficulties	Children began independently correcting mistakes (rebuilding structures, repeating experiments)	Increased self-correction and reflective thinking

b) Development of Sequencing Skills

Before participating in STEAM-unplugged activities, children demonstrated limited ability to organize steps in logical order. For instance, during initial observations, many children constructed structures or carried out simple science tasks without attention to procedural flow. They also tended to jump between steps or reverse orders, resulting in structural instability or incomplete tasks.

Following the intervention, children displayed stronger ordering behaviors. In block-building tasks, they began identifying foundational steps first, such as placing larger blocks at the bottom, followed by smaller blocks. During art-based sequences—such as arranging materials for collage making—children planned the layout before attaching items. Similarly, in simple scientific explorations like "planting seeds", they followed correct sequences: preparing soil → placing seed → watering → monitoring.

A key factor contributing to this improvement was the integrated nature of STEAM activities. Activities involved procedural thinking embedded naturally within tasks. For example, engineering challenges required children to think step-by-step, while mathematics components reinforced ordering through number sequencing and logical arrangement.

The results confirm that unplugged STEAM activities are effective in strengthening sequencing abilities through embodied and manipulative learning experiences.

c) Enhancement of Pattern Recognition

Prior to the intervention, children could identify basic patterns (e.g., AB or ABC sequences) but often struggled to extend, generalize, or apply patterns in new contexts. Pattern recognition was inconsistent, particularly when patterns involved multiple variables such as color-size-shape combinations.

After the intervention, children exhibited improved pattern recognition across multiple STEAM domains. During art activities, children recreated patterns using various materials such as colored sticks, beads, or paper shapes. In mathematics-focused tasks, they extended sequences more accurately and predicted the "next element" in a pattern with greater confidence. In science-related observations—such as watching water movement or noticing shadow growth—children identified natural patterns and described them in their own words.

This improvement suggests that pattern recognition is strengthened when children encounter patterns across diverse learning situations rather than in isolated lessons. STEAM activities naturally expose children to recurring structures and relationships, enabling them to form mental models that support CT development.

d) Growth in Problem Solving and Debugging Abilities

Before the STEAM-based unplugged intervention, children typically depended on adult direction when tasks became challenging. They displayed limited persistence and rarely attempted to revise their own mistakes. For example, when building structures toppled or when experimental results differed from expectations, many children waited for teacher guidance instead of re-evaluating their approach.

Post-intervention observations showed significant growth. Children attempted multiple strategies before seeking help. They experimented with modifying structures, adjusting materials, or repeating procedures until achieving successful outcomes. They also began verbalizing their thought processes, an important marker of developing metacognition.

Debugging behaviors were particularly evident in engineering challenges. When a tower fell, children adjusted block placement. When a water path did not flow as intended, they changed the angle or material. These iterative behaviors mirror the debugging process in computational thinking, suggesting that unplugged activities provide an age-appropriate pathway for cultivating self-directed problem solving.

e) Cross-Indicator Improvement and Holistic CT Development

Although the indicators are discussed separately for analytical clarity, improvements were interconnected. Sequencing supported problem solving because children who planned steps effectively were better equipped to evaluate errors. Pattern recognition enhanced debugging because children who noticed recurring outcomes could predict and adjust strategies.

Thus, the intervention fostered holistic **computational thinking**, not simply isolated skills. The interconnected nature of STEAM domains facilitated this holistic development by engaging children in integrated thinking processes.

5.

Figure 1. Children work together to make shapes from Lego

1.

Figure 2. The process of making a simple windmill from origami

Figure 3. When children play angklung with a code from the coach

2. *Discussion*

The findings indicate that STEAM-unplugged activities serve as a meaningful catalyst for early computational thinking (CT) development, not merely by generating observable improvements, but by shaping the underlying cognitive processes that enable CT to emerge. Rather than functioning as isolated tasks, STEAM-based activities offer children opportunities to coordinate multiple modes of reasoning—sensory, spatial, logical, and reflective. This integrative nature helps explain why children's CT skills developed even in the absence of digital tools.

A deeper interpretation suggests that unplugged STEAM activities allow children to construct computational ideas through concrete, embodied engagement. Manipulating materials, predicting outcomes, and iteratively refining their actions mirrors the epistemic processes inherent in CT. Thus, the effectiveness of unplugged CT learning lies not only in the activities themselves but in the way these activities scaffold cognitive habits such as systematic reasoning, iterative inquiry, and reflective thinking.

Beyond the improvement in sequencing observed in the results, a critical interpretation is that sequencing emerges as children learn to coordinate temporal logic with physical action. STEAM tasks require children to plan, anticipate consequences, and revise procedural steps when outcomes do not align with expectations. These demands stimulate the development of procedural thinking. The relational meaning of sequencing becomes clearer when children experience the consequences of misordered steps. Rather than memorizing instructions, they develop *situated procedural reasoning*—an understanding of "what must come before what" based on causal structures embedded in STEAM tasks. This suggests that sequencing development is not merely a skill learned but a reasoning pattern constructed through embodied interaction with materials and problemsThe strengthening of pattern recognition reflects not only exposure to repeated structures but also the cognitive integration of patterns across multiple domains. STEAM activities enable children to move from surface-level recognition (e.g., repeated colors or shapes) toward more abstract pattern generalization. This conceptual shift indicates early forms of abstraction, which is foundational to higher-order CT.

The interpretive significance lies in how children applied patterns across different contexts—mathematics, art, and natural phenomena. This cross-contextual application demonstrates that children were not merely memorizing patterns but constructing generalized pattern schemas. Such schemas support predictive reasoning and transfer, both critical to computational thinking.Debugging behaviors observed in this study can be interpreted as manifestations of emerging cognitive flexibility. When children encounter errors, they are compelled to reconsider assumptions, test alternative strategies, and evaluate outcomes. This reflective process represents early metacognitive engagement. Importantly, debugging in unplugged STEAM environments highlights that young children are capable of monitoring their own thinking when tasks are structured to encourage experimentation. The shift from viewing mistakes as failures to treating them as opportunities reflects the development of a growth-oriented problem-solving mindset. This mindset is essential for long-term CT progression.

The value of unplugged CT learning extends beyond skill acquisition. It demonstrates that CT can be embedded within developmentally appropriate pedagogies that respect children's need for sensory, social, and exploratory learning. A deeper implication is that early CT development does not require technological dependence. Instead, what matters is the cognitive architecture of the learning experience. This finding challenges prevailing assumptions that digital tools are necessary for CT, emphasizing that pedagogical design is more influential than technological availability. For early childhood settings—especially those with limited digital resources—this offers an equitable, accessible model for CT integration.

3. *Conclusion*

The findings of this study indicate that the stimulation of computational thinking in early childhood at Angkasa Lanud Adisucipto Yogyakarta Kindergarten emerges through a combination of structured **play**, art-based activities, music exploration, and outdoor learning experiences. Rather than relying on digital devices, the school strategically integrates STEAM-based unplugged activities that allow children to engage in hands-on manipulation, problem solving, and sequential reasoning. This approach reflects the institution's commitment to preparing children with foundational 21st-century competencies by ensuring that learning activities are varied, developmentally appropriate, and not monotonous.

More importantly, the study demonstrates that unplugged STEAM tasks can significantly support the development of early computational thinking. Children showed the ability to follow multistep instructions, identify patterns, and engage in trial-and-error processes—indicating the emergence of sequencing, pattern recognition, and debugging skills. These outcomes suggest that computational thinking can be effectively nurtured even in settings with limited access to technology, provided that activities are intentionally designed to target CT indicators.

4. *References*

Anabousy, A., & Daher, W. (2022). Prospective teachers' design of STEAM learning units: STEAM capabilities' analysis. *Journal of Technology and Science Education*, *12*(2), 529. https://doi.org/10.3926/jotse.1621

Badawi, W. S. (2022). Implementasi Ekstrakurikuler Angklung pada Anak Usia Dini di Kelompok Bermain Tunas Harapan SKB Kabupaten Sleman. *JSCE: Journal of Society and Counting Education*, *3*(3), 438–445.

Barradas, R., Lencastre, J., Soares, S., & Valente, A. (2020). Developing Computational Thinking in Early Ages: A Review of the code.org Platform. *Proceedings of the 12th International Conference on Computer Supported Education*, *2*(January), 157–168. https://doi.org/https://doi.org/10.7195/ri14.v19i2.1653

Belbase, S., Mainali, B. R., Kasemsukpipat, W., Tairab, H., Gochoo, M., & Jarrah, A. (2022). At the dawn of science, technology, engineering, arts, and mathematics (STEAM) education: prospects, priorities, processes, and problems. *International Journal of Mathematical Education in Science and Technology*, *53*(11), 2919–2955. https://doi.org/10.1080/0020739X.2021.1922943

Bers, M. U. (2018). Coding and Computational Thinking in Early Childhood: The Impact of ScratchJr in Europe. *European Journal of STEM Education*, *3*(3).

Bers, M. U., González-González, C., & Armas–Torres, M. B. (2019). Coding as a Playground: Promoting Positive Learning Experience in Childhood Classroom. *Computers & Education*, *138*, 130–145. https://doi.org/10.1016/j.compedu.2019.04.013

Brackmann, C. P., Román-González, M., Robles, G., Moreno-León, J., Casali, A., & Barone, D. (2017). Development of Computational Thinking Skills through Unplugged Activities in Primary School. *Proceedings of the 12th Workshop on Primary and Secondary Computing Education, WiPSCE '17, Netherland.* https://doi.org/10.1145/3137065.3137069

Burnard, P., Colucci-Gray, L., & Cooke, C. (2022). Transdisciplinarity: Re-Visioning How Sciences and Arts Together Can Enact Democratizing Creative Educational Experiences. *Review of Research in Education*, *46*(1), 166–197. https://doi.org/10.3102/0091732X221084323

Cansu, S. K., & Cansu, F. K. (2019). An Overview of Computational Thinking. *International Journal of Computer Science Education in Schools*, *3*(1), 1–11. https://doi.org/10.21585/ijcses.v3i1.53

Carter, C. E., Barnett, H., Burns, K., Cohen, N., Durall, E., Lordick, D., Nack, F., Newman, A., & Ussher, S. (2021). Defining STEAM Approaches for Higher Education. *European Journal of STEM Education*, *2021*(1), 13. https://doi.org/10.20897/ejsteme/11354

Cheng, L., Wang, M., Chen, Y., Niu, W., Hong, M., & Zhu, Y. (2022). Design My Music Instrument: A Project-Based Science, Technology, Engineering, Arts, and Mathematics Program on The Development of Creativity. *Frontiers in Psychology*, *12*(January). https://doi.org/10.3389/fpsyg.2021.763948

ElSayary, A., Zein, R., & San Antonio, L. (2022). Using Interactive Technology to Develop Preservice Teachers' STEAM Competencies in Early Childhood Education Program. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(2), em2079. https://doi.org/10.29333/ejmste/11649

Harahap, N. (2020). *Penelitian Kualitatif*. Wal Ashri Publishing.

Hasjiandito, A., Waluyo, E., Sulistio, B., & Purwanti, A. (2024). Pelatihan Pengembangan Aplikasi Game Tematik Berbasis Visual Coding untuk Guru TK di Provinsi Jawa Tengah. *J-Dinamika: Jurnal Pengabdian Masyarakat*, *9*(2), 304–311.

Hsiao, H.-S., Chen, J.-C., Chen, J.-H., Zeng, Y.-T., & Chung, G.-H. (2022). An Assessment of Junior High School Students' Knowledge, Creativity, and Hands-On Performance Using PBL via Cognitive–Affective Interaction Model to Achieve STEAM. *Sustainability*, *14*(9), 5582. https://doi.org/10.3390/su14095582

Hsiao, P.-W., & Su, C.-H. (2021). A Study on the Impact of STEAM Education for Sustainable Development Courses and Its Effects on Student Motivation and Learning. *Sustainability*, *13*(3772), 1–24.

Hsu, T.-C., Chang, Y.-S., Chen, M.-S., Tsai, I.-F., & Yu, C.-Y. (2022). A validity and reliability study of the formative model for the indicators of STEAM education creations. *Education and Information Technologies*, *0123456789*. https://doi.org/10.1007/s10639-022-11412-x

Huang, W., & Looi, C.-K. (2020). A Critical Review of Literature on "Unplugged" Pedagogies in K-12 Computer Science and Computational Education. *Computer Science Education*, *14*(7), 1–29. https://doi.org/10.1080/08993408.2020.1789411

Hussain, S., Papadakis, S., Rojabi, A. R., Setiawan, S., Munir, A., Purwati, O., Safriyani, R., Hayuningtyas, N., Khodijah, S., & Amumpuni, R. S. (2022). *Kahoot, is it fun or unfun? Gamifying vocabulary learning to boost exam scores, engagement, and motivation*. https://doi.org/10.3389/feduc.2022.939884

Kurniawan, E. Y. (2019). Upaya Pewarisan Kesenian Tradisional ditengah Zaman Milenial melalui Pembelajaran Angklung pada Siswa Kelas XII IPA SMAN 13 Kabupaten Tangerang. *JPKS (Jurnal Pendidikan Dan Kajian Seni)*, *4*(1), 1–11.

Lee, J. (2019). Coding in early childhood. *Contempory Issues in Early Childhood*, *21*(3), 266–269. https://doi.org/10.1177/1463949119846541

Lee, V. R., & Recker, M. (2018). Paper Circuits: A Tangible, Low Threshold, Low Cost Entry to Computational Thinking. *TechTrends*, *62*(2), 197–203. https://doi.org///doi.org/10.1007/s11528-017-0248-3

Masarwa, B., Hel-Or, H., & Levy, S. T. (2024). Kindergarten Children's Learning of Computational Thinking with the "Sorting Like a Computer" Learning Unit. *Journal of Research in Childhood Education*, *38*(2), 165–188. https://doi.org/10.1080/02568543.2023.2221319

Ningtyas, D. P., Setyosari, P., Kuswandi, D., & Ulfa, S. (2024). Enhancing Early Childhood Problem-Solving Abilities through Game-Based Learning and Computational Thinking: The Impact of Cognitive Styles. *Golden Age: Jurnal Ilmiah Tumbuh Kembang Anak Usia Dini*, *9*(3), 409–419. https://doi.org/10.14421/jga.2024.93-04

Poon, S. T. F. (2018). LEGO as a Learning Enabler in the 21st-Century Preschool Classroom: Examining Perceptions of Attitudes and Preschool Practices. *Journal of Urban Culture Research*, *Desember*, 72–87. https://doi.org/10.14456/jucr.2018.12

Relkin, E., Ruiter, L. de, & Bers, M. U. (2020). TechCheck: Development and Validation of an Unplugged Assessment of Computational Thinking in Early Childhood Education. *Jornal of Science Educational and Technology*, *29*(4), 482–498.

Rodríguez-Nieto, C. A., & Alsina, Á. (2022). Networking Between Ethnomathematics, STEAM Education, and the Globalized Approach to Analyze Mathematical Connections in Daily Practices. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(3), em2085. https://doi.org/10.29333/ejmste/11710

Roman-Gonzalez, M., Perez-Gonzalez, J.-C., & Jimenez-Fernandez, C. (2016). Which Cognitive Abilities Underlie Computational Thinking? Criterion Validity of the Computational Thinking Test. *Computers in Human Behavior*, 1–14. https://doi.org/10.1016/j.chb.2016.08.047

Saxena, A., Lo, C. K., Hew, K. F., & Wong, G. (2020). Designing Unplugged and Plugged Activities to Cultivate Computational Thinking: An Exploratory Study in Early Childhood Education. *The Asia-Pacific Education Researcher*, *29*(1), 55–66. https://doi.org/10.1007/s40299-019-00478-w

Setianingrum, I., & Hidayana, A. F. (2025). Pengaruh Pemahaman Guru PAUD terhadap Pembelajaran Coding Anak Usia Dini. *Jurnal Care: Children Advisory Research and Education*, *13*(1), 90–100.

Su, J., & Yang, W. (2023). A systematic review of integrating computational thinking in early childhood education. *Computers and Education Open*, *4*(August 2022), 100122. https://doi.org/10.1016/j.caeo.2023.100122

Taibo, H., & Liang, C. (2022). Research on the Training Mode of Children's Engineering Thinking with the Concept of STEAM Education. *Journal of Curriculum and Teaching*, *11*(7), 7–14. https://doi.org/10.5430/JCT.V11N7P7

Tengler, K., Kastner-Hauler, O., & Sabitzer, B. (2021). Enhancing Computational Thinking Skills using Robots and Digital Storytelling. *Proceedings of the 13th International Conference on Computer Supported Education*, *1*(Csedu), 157–164. https://doi.org/10.5220/0010477001570164