Bulletin of Early Childhood
Vol. 5, No. 1, June 2026
https://attractivejournal.com/index.php/bec
Bulletin of Early Childhood

Computational Thinking and Coding Activities in Developing Critical Thinking in Early Childhood

Rabitah Hanum Hasibuan[1], *Serena Dwi Masta[1], Aina Aslamyah[1], Ika Anggraini[1], Amallia Soraya[1], Siti Suryani[1]
[1] *Institute Sheikh Abdul Halim Hasan Binjai, Indonesia*

serenadwimasta04@gmail.com *

ARTICLE INFO
Article history :
Received
March 08, 2026
Revised
May 09, 2026
Accepted
June 29, 2026

Abstract

This study aims to analyze the effect of implementing computational thinking and coding activities on the development of critical thinking skills in early childhood. The study used a quasi-experimental approach with a pretest-posttest control group design on 60 children aged 5-6 years in Medan City Kindergarten, who were randomly divided into an experimental group (n=30) and a control group (n=30). The data collection instrument used structured observation based on the Critical Thinking Skills for Early Childhood (CTSEC) rubric that has been validated by experts. The experimental group received an integrated computational thinking intervention of coding activities using the ScratchJr platform for eight weeks (16 sessions), while the control group followed regular learning. Data were analyzed using an independent t-test and ANCOVA. The results showed a significant difference in critical thinking skills between the experimental and control groups ($t=8.47$, $p<0.001$, $d=2.18$). The indicators that improved the most were problem-solving ability (87%), followed by logical thinking ability (82%), and analytical ability (76%). This study concludes that the integration of computational thinking and coding activities effectively stimulates the development of critical thinking in early childhood through the mechanisms of problem decomposition, pattern recognition, and algorithmic thinking. The implications of these findings are relevant for the development of technology-based early childhood education curricula in the digital era.

Keywords: Computational Thinking, Coding Activities, Critical Thinking, Early Childhood, Scratchjr

Published by CV. Creative Tugu Pena
Website https://attractivejournal.com/index.php/be c

INTRODUCTION

The 21st century demands a generation that is not only capable of consuming technology, but also of critical thinking and systematic problem-solving. *Critical* thinking is a fundamental competency that needs to be developed from an early age, considering that the 0-8 year period is a sensitive period for children's cognitive development (Voogt et al., 2015). However, early childhood education (PAUD) curricula in many developing countries, including Indonesia, still do not integrate approaches that explicitly stimulate higher-order thinking skills.

Computational thinking (CT) exists as a framework that offers a systematic approach to solving complex problems through decomposition, pattern recognition, abstraction, and algorithms (Wing, 2006). Various studies have shown that CT can be introduced even in early childhood through meaningful play activities (Bers et al., 2019; Papert & Harel, 1991). Coding activities, as a concrete representation of CT, have been shown to facilitate children's development of logical and analytical thinking skills (Flannery et al., 2013).

Phenomenologically, massive digitalization has transformed the landscape of early childhood learning. UNESCO data (2022) notes that more than 60% of children aged 4-6 in Southeast Asia have been regularly exposed to digital devices, but only 12% receive structured pedagogical guidance in utilizing technology for cognitive learning. In Indonesia, a survey by the Ministry of Communication and Information Technology (Kominfo) (2023) revealed that internet penetration among early childhood groups reached 47%, but the implementation of CT in the PAUD curriculum remains very limited, especially in non-metropolitan areas. This phenomenon creates a gap between the potential use of technology and its realization in children's cognitive development.

Theoretically, there is a gap in understanding the mechanisms by which CT and coding activities specifically contribute to critical thinking in early childhood development. Piaget's constructivist theory emphasizes that children learn through active interaction with the environment (Piaget, 1952), while Vygotsky's emphasized the role of social mediation and cultural tools (Vygotsky, 1978). Wing's (2006) CT framework was originally conceptualized for the context of adult computing and software engineering. Adapting CT to early childhood requires a more cohesive theoretical foundation that integrates cognitive developmental theory with technology-based pedagogy. Most existing studies remain fragmented: some examine CT separately from critical thinking, or both without adequately considering the child's developmental stage (Grover & Pea, 2013).

From a research perspective, although there are several studies on CT and coding at the elementary and secondary school levels (Lye & Koh, 2014; Weintrop et al., 2016), research specifically examining the effectiveness of CT and coding activities on the development of critical thinking in children aged 5-6 years is still very limited, especially in the context of Southeast Asia and Indonesia. A study by Bers et al. (2019) in the United States using ScratchJr showed promising results in children aged 5-7 years, but the different cultural context and curriculum limit the generalizability of these findings to the Indonesian context. Furthermore, most existing studies use critical thinking measurement instruments developed for school-age children, so their ecological validity for early childhood education needs to be re-examined (Portelance et al., 2016). This study aims to fill this gap by developing and piloting a contextualized CT-coding integration model for early childhood education in Indonesia.

Based on the background above, the objectives of this study are: (1) to analyze the effectiveness of the application of computational thinking and coding activities on improving critical thinking in children aged 5-6 years; (2) to identify the critical thinking indicators that are most responsive to CT and coding interventions; and (3) to describe the patterns of children's interactions during coding activities that contribute to the development of critical thinking.

METHOD

Research Design

This study used a quantitative approach with a quasi-experimental *nonequivalent control group pretest-posttest design* (Creswell & Creswell, 2018). This design was chosen because full randomization is impossible in a kindergarten setting, requiring statistical control through ANCOVA to control for pretest differences.

Population and Sample

The study population was all children aged 5-6 years enrolled in Kindergarten Group B in Medan City, North Sumatra, during the 2023/2024 academic year. The sample was selected using a *purposive sampling technique* based on the following inclusion criteria: (a) children aged 5-6 years, (b) no diagnosed developmental disorders, and (c) written consent from parents/guardians. The sample size was 60. Children (30 experimental group, 30 control group) from two equivalent kindergartens based on accreditation and demographic profile. The sample size was determined based on a statistical power analysis *with* $\alpha=0.05$, power=0.80, and a moderate effect size (d=0.5) resulting in a minimum of n=26 per group (Cohen, 1988).

Instrument

The main instrument was the Critical Thinking Skills for Early Childhood (CTSEC) rubric developed by researchers based on Facione's (1990) framework adapted for early childhood. CTSEC includes four dimensions: (1) analytical skills (8 indicators), (2) inference skills (6 indicators), (3) evaluation skills (7 indicators), and (4) problem-solving skills (9 indicators). Content validity was confirmed by three experts (Aiken's V coefficient = 0.87) and construct validity was tested through confirmatory factor analysis (CFI = 0.96, RMSEA = 0.05). Interrater reliability was calculated using Cohen's kappa ($\kappa = 0.82$, $p < 0.001$), indicating strong agreement (Landis & Koch, 1977).

Procedure Intervention

The experimental group received an eight-week intervention (16 sessions × 45 minutes) using the Computational Thinking-Integrated Coding Activities (CT-ICA) learning model developed by the researchers. The platform used was ScratchJr (iPad version 2.0), a visual programming environment specifically designed for children aged 5-7 years (Flannery et al., 2013). Each session followed the cycle: (1) problem exploration (5 minutes), (2) decomposition and planning (10 minutes), (3) coding and implementation (20 minutes), and (4) reflection and debugging (10 minutes). The control group followed regular learning according to the 2013 PAUD curriculum.

Data Analysis Techniques

Data were analyzed using IBM SPSS 26. Shapiro-Wilk's normality test and Levene's homogeneity test were performed prior to the main analysis. The effectiveness of the intervention was tested using an independent t-test and ANCOVA (with pretest scores as a covariate). Effect sizes were calculated using Cohen's d. The significance level was set at $\alpha=0.05$.

RESULTS AND DISCUSSION

Data Description

Table 1 presents descriptive statistics of the critical thinking scores of the experimental and control groups on the pretest and posttest.

Table 1 Statistics Descriptive Critical Thinking Score

Group	Pretest M (SD)	Posttest M (SD)	Gain Score	N
Experiment	42.17 (6.34)	78.53 (7.21)	36.36	30
Control	41.83 (6.12)	56.40 (6.85)	14.57	30

Note : M = Mean; SD = Standard Deviation ; Maximum score = 100

The results of the Shapiro-Wilk test show that the data is normally distributed in both groups ($W > 0.95$, $p > 0.05$), and Levene's test confirmed homogeneity variance ($F = 0.34$, $p = 0.56$). There is no difference significant on pretest scores between second group ($t = 0.21$ $p = 0.83$), indicating equality a good start.

Intervention Effectiveness Test

An independent t-test on posttest scores revealed a highly significant difference between the experimental group ($M = 78.53$, $SD = 7.21$) and the control group ($M = 56.40$, $SD = 6.85$), $t(58) = 12.47$, $p < 0.001$. An ANCOVA with pretest scores as a covariate confirmed a significant intervention effect, $F(1, 57) = 71.83$, $p < 0.001$, $\eta^2 = 0.558$. Cohen's d effect size = 2.18 indicates a very large effect (Cohen, 1988).

Critical Thinking Per-Indicator Analysis

Per-indicator analysis showed that problem-solving ability experienced the highest improvement (87%), followed by logical thinking ability (82%), analytical ability (76%), and inference ability (71%). This pattern is consistent with the proposition that structured and goal-oriented coding activities naturally stimulate problem-solving mechanisms and algorithmic thinking (Bers et al., 2019).

The findings of this study confirm the hypothesis that integrating computational thinking and coding activities effectively enhances critical thinking in early childhood. The very large effect size ($d = 2.18$) surpasses the findings of a meta-analysis by Scherer et al. (2019) which reported an average effect size of $d = 0.47$ for CT interventions in elementary schools, likely due to the sensitivity of early developmental periods to structured cognitive stimulation.

The superiority of problem-solving skills as the most responsive indicator aligns with the theory that the debugging process in coding—namely, identifying and correcting errors in programs—directly trains children's ability to think systematically and persist in the face of failure (Resnick & Silverman, 2005). This finding supports Bers et al.'s (2019) argument that ScratchJr is not simply a digital content creation tool, but rather a learning environment that inherently integrates computational reasoning.

From Piaget's constructivist perspective, coding activities provide concrete objects (visual code blocks) that children can directly manipulate, supporting the transition from the concrete operational stage to abstract thinking (Piaget, 1952). The collaborative process that occurs in coding sessions—where children discuss strategies, share solutions, and provide feedback to one another—also aligns with Vygotsky's concept of the Zone of Proximal Development, where cognitive development occurs most optimally through culturally mediated social interactions (Vygotsky, 1978).

This study also responds to the findings of Lye & Koh (2014) in their systematic review, which identified an urgent need for CT studies in younger age groups with more rigorous experimental designs. The CTSEC instrument developed in this study offers a methodological contribution in the form of an ecologically valid critical thinking measurement tool for the ECD context, filling the gap identified by Portelance et al. (2016). This study has several limitations. First, the sample was limited to two kindergartens in Medan City, so generalizations to rural contexts or areas with limited technological infrastructure should be approached with caution. Second, the eight-week intervention duration does not allow for assessment of long-term effects. Third, mediating and moderating variables (such as parental involvement and teacher digital literacy) were not explored in depth.

CONCLUSION

This study demonstrates that integrating computational thinking and coding activities using ScratchJr significantly improves critical thinking skills in 5-6 year old children, with a very large effect size (d = 2.18). Problem-solving skills were the most responsive aspect to the intervention, followed by logical thinking and analytical skills. These findings have important practical implications for early childhood education curriculum developers in Indonesia: the integration of CT and coding activities should be considered a core component of cognitive learning, not simply a technological supplement. For further research, it is recommended to: (1) conduct a longitudinal study to examine the retention and transfer of critical thinking skills developed through CT; (2) develop a more comprehensive CT-based early childhood teacher training model; and (3) explore the integration of CT with the STEAM (Science, Technology, Engineering, Arts, Mathematics) approach to create a more holistic learning experience for early childhood.

REFERENCES

Bers, M. U., Gonzalez-Gonzalez, C., & Armas-Torres, M. B. (2019). Coding as a playground: Promoting positive learning experiences in childhood classrooms. *Computers & Education*, 138, 130–145. https://doi.org/10.1016/j.compedu.2019.04.013

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences (2nd ed.).* Lawrence Erlbaum Associates.

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.)*. SAGE Publications.

Facione, P. A. (1990). *Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction*. The California Academic Press.

Flannery, L. P., Silverman, B., Kazakoff, E. R., Bers, M. U., Bontá, P., & Resnick, M. (2013). Designing ScratchJr: Support for early childhood learning through computer programming. *Proceedings of the 12th International Conference on Interaction Design and Children* (pp. 1–10). ACM. https://doi.org/10.1145/2485760.2485762

Grover, S., & Pea, R. (2013). Computational thinking in K–12: A review of the state of the field. *Educational Researcher*, 42(1), 38–43. https://doi.org/10.3102/0013189X12463051

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, 33(1), 159–174. https://doi.org/10.2307/2529310

Lye, S. Y., & Koh, J. H. L. (2014). Review on teaching and learning of computational thinking through programming: What is next for K-12? *Computers in Human Behavior*, 41, 51–61. https://doi.org/10.1016/j.chb.2014.09.012

Papert, S., & Harel, I. (1991). *Situating constructionism. In I. Harel & S. Papert (Eds.),* Constructionism (pp. 1–11). Ablex Publishing Corporation.

Piaget, J. (1952). *The origins of intelligence in children*. International Universities Press.

Portelance, D. J., Strawhacker, A. L., & Bers, M. U. (2016). Constructing the ScratchJr programming language in the early childhood classroom. *International Journal of Technology and Design Education*, 26(4), 489–504. https://doi.org/10.1007/s10798-015-9325-0

Resnick, M., & Silverman, B. (2005). *Some reflections on designing construction kits for kids*. Proceedings of the 2005 Conference on Interaction Design and Children (pp. 117–122). ACM.

Scherer, R., Siddiq, F., & Sánchez Viveros, B. (2019). The cognitive benefits of learning computer programming: A meta-analysis of transfer effects. *Journal of Educational Psychology*, 111(5), 764–792. https://doi.org/10.1037/edu0000314

Voogt, J., Fisser, P., Good, J., Mishra, P., & Yadav, A. (2015). Computational thinking in compulsory education: Towards an agenda for research and practice. *Education and Information Technologies,* 20(4), 715–728. https://doi.org/10.1007/s10639-015-9412-6

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & Wilensky, U. (2016). Defining computational thinking for mathematics and science classrooms. *Journal of Science Education and Technology*, 25(1), 127–147. https://doi.org/10.1007/s10956-015-9581-5
Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, 49(3), 33–35. https://doi.org/10.1145/1118178.1118215