

THE EFFECT OF UNPLUGGED CODING ON NUMBER-CONCEPT UNDERSTANDING IN CHILDREN AGED 5–6 YEARS

Fitriah Rahmadani^{1*} Sitti Nurhidayah Ilyas² Rika Kurnia³

¹²³Universitas Negeri Makassar, Indonesia

*Corresponding Author: fitiahrhmdn23@gmail.com

ABSTRACT

Early numeracy is a foundational component of school readiness, and developmentally appropriate coding activities may provide concrete opportunities to practice order, symbol–quantity relations, and sequential reasoning. This study examined whether unplugged coding learning was associated with higher number-concept understanding among children aged 5–6 years. A quantitative quasi-experimental nonequivalent control-group design involved 30 children, with 15 children in an experimental group and 15 in a control group. Number-concept understanding was observed through number recognition, number sequencing, and matching quantities with number symbols. Both groups completed a pretest and posttest; the experimental group received unplugged coding learning and the control group received conventional learning. The experimental-group mean increased from 18.27 to 31.93, whereas the control-group mean increased from 19.00 to 20.67. The reported posttest comparison was statistically significant, $t(28) = 12.093$, $p < .001$, with a mean difference of 11.267 and an approximate 95% confidence interval of [9.36, 13.18]. A derived small-sample standardized difference was very large (Hedges' $g = 4.30$). The findings indicate a substantial between-group posttest difference in this sample and support further investigation of unplugged coding as a play-based early-numeracy strategy. Causal and generalizable conclusions remain limited by the small, single-site, nonequivalent-group design and incomplete reporting of the intervention and measurement procedures.

Keywords: computational thinking, early childhood education, early numeracy, number-concept understanding, unplugged coding

INTRODUCTION

Early childhood is a foundational period for the development of mathematical knowledge, and early numeracy is especially consequential because it supports children's later engagement with formal mathematics. Number-concept understanding in the preschool and kindergarten years includes recognizing numerals, linking spoken and written number symbols with quantities, maintaining stable order, sequencing numbers, and coordinating one-to-one correspondence. Longitudinal research has repeatedly shown that mathematics knowledge at school entry is strongly associated with later academic achievement. Duncan et al. (2007), using multiple longitudinal datasets, identified school-entry mathematics as one of the strongest predictors of later achievement, while Jordan et al. (2006) demonstrated meaningful growth trajectories in kindergarten number sense. More specifically, Nguyen et al. (2016) found that preschool numeracy, particularly more advanced counting competencies, predicted mathematics achievement several years later. These findings reinforce the importance of providing young children with rich, developmentally sequenced opportunities to construct number meaning rather than treating early mathematics as memorization of symbols or routines.

Learning-trajectory research provides a useful conceptual basis for such instruction. Clements and Sarama (2004) argued that effective mathematics education connects children's existing ways of thinking with progressively more sophisticated mathematical ideas through carefully sequenced learning experiences. Their later synthesis of early mathematics interventions likewise emphasized that preschool children are capable of substantial mathematical learning when instruction is intentionally designed and responsive to developmental pathways (Clements & Sarama, 2011). In the Indonesian early-childhood context, concrete and engaging experiences have also been emphasized as supports for

cognitive development and early number learning (Haryono et al., 2024; Ilyas & Alriani, 2021). For children aged 5–6 years, symbolic representation is expanding, yet understanding continues to benefit from manipulation, movement, visual cues, play, and immediate feedback. This makes activities that connect bodily action, objects, sequences, and symbols particularly relevant to number-concept learning.

Evidence from embodied and physically integrated learning is consistent with this developmental rationale. In a randomized preschool study, Mavilidi et al. (2018) reported that numeracy learning was stronger when physical movements were meaningfully integrated with the learning content than under comparison conditions. Such evidence does not imply that movement alone produces mathematical understanding; rather, it suggests that task-relevant action can help children coordinate abstract concepts with perceptible events. For number concepts, this coordination can occur when children move a specified number of steps, place objects in order, pair one action with one symbol, or physically enact a sequence. These forms of activity are also characteristic of many unplugged coding tasks, creating a potential bridge between computational processes and early mathematics.

Computational thinking has become an increasingly prominent area of educational research. Although definitions vary, computational thinking commonly includes processes such as decomposition, pattern recognition, sequencing, algorithmic thinking, representation, and debugging (Grover & Pea, 2013). Early-childhood research indicates that these processes can be introduced in age-appropriate ways when coding is treated not as advanced syntax but as a symbolic and problem-solving language grounded in play and tangible activity. Bers (2019) described coding as another language through which young children can represent and communicate ideas, while Su and Yang (2023), in a systematic review of early-childhood computational-thinking education, concluded that developmentally appropriate instructional design can support young children's computational concepts as well as related problem-solving and collaborative skills. Guided-play research similarly shows that preschool children can engage with basic programming concepts when activities are scaffolded and matched to their developmental level (Critten et al., 2022).

Unplugged coding is especially relevant for early-childhood settings because computational ideas are represented without requiring a computer, tablet, or conventional programming interface. Typical activities use arrows, cards, floor grids, movement, patterns, routes, stories, rule-based games, and ordered commands. Lee and Jo (2019) showed how unplugged coding can be implemented in an early-childhood classroom, and Saxena et al. (2020) designed unplugged and plugged activities around pattern recognition, sequencing, and algorithm design for preschoolers. Across a wider educational literature, Brackmann et al. (2017) reported gains in computational-thinking skills through unplugged activities, while Chen et al. (2023) synthesized evidence showing an overall positive effect of unplugged approaches on computational-thinking outcomes, with meaningful variation across designs and contexts. The pedagogical appeal of unplugged coding therefore lies not only in the absence of screens but in its capacity to make abstract computational relationships observable through action and concrete materials.

Research involving young children also demonstrates that coding-related learning can support several cognitive processes that are plausibly related to early mathematics. Bers et al. (2014) documented young children's engagement with foundational programming and robotics concepts in kindergarten classrooms. Kazakoff et al. (2013) reported improved sequencing performance after an intensive early-childhood robotics and programming experience, and Sullivan and Bers (2016) showed that children from pre-kindergarten through second grade could learn foundational robotics and programming concepts through a structured curriculum. Other studies have found that young children can solve problems within programming environments (Fessakis et al., 2013), acquire foundational coding skills

through child-oriented applications (Pila et al., 2019; Papadakis et al., 2016), and develop problem-solving or creative-thinking outcomes through robotics and coding experiences (Çakır et al., 2021). These studies collectively support the feasibility of introducing computational ideas in early childhood, while also showing that the specific learning outcomes depend on task design, instructional support, and the constructs assessed.

The possible relationship between coding and number-concept understanding is more specific than a general claim that coding improves cognition. Sequencing a set of commands requires attention to order; matching an arrow or symbol to an action requires representational mapping; navigating a route requires one-to-one correspondence between instructions and movements; and detecting patterns requires recognition of regularity and relational structure. Gerosa et al. (2021) provided direct evidence that computational-thinking performance at age five was associated with temporal sequencing and symbolic number comparison. Yang et al. (2023) likewise found that computational thinking was positively associated with sequencing ability among young children. These findings are correlational and do not establish that coding causes number-concept growth, but they strengthen the theoretical plausibility that activities organized around sequence, symbols, and ordered actions may overlap with cognitive operations involved in early numeracy.

Within Indonesia, early studies have begun to examine unplugged coding in early-childhood education. Mutoharoh et al. (2021) reported the use of unplugged activities for young children's problem-solving skills, Fitriyah et al. (2023) described daily-life-based unplugged coding as a feasible way to foster computational thinking, and Oktaviani et al. (2025) examined computational and collaborative thinking through unplugged coding. Yücelyiğit (2023) also documented coding practices and teacher perspectives in early-childhood classrooms outside Indonesia, illustrating broader international interest in developmentally appropriate coding. A recent review by Damayanti et al. (2026) indicates continuing growth in research on plugged and unplugged coding for children aged 4–6 years, while highlighting the importance of contextual factors and resource conditions. Nevertheless, a large proportion of this literature measures computational thinking, programming knowledge, collaboration, or problem solving rather than number-concept understanding as the primary outcome.

This distinction defines the research gap addressed in the present study. The expected condition is that early mathematics experiences should be concrete, developmentally appropriate, and sufficiently rich to connect numerical symbols, quantities, and ordered relations; the empirical condition is that evidence remains limited on whether unplugged coding is associated with improved number-concept understanding among Indonesian children aged 5–6 years when compared with a control group. The novelty of the study is therefore not the general introduction of coding to young children, which has already been widely explored, but the direct focus on number recognition, number sequencing, and quantity–symbol matching as the measured outcome of an unplugged coding intervention in an Indonesian early-childhood setting. The study aimed to examine the difference in number-concept understanding between children exposed to unplugged coding learning and children receiving conventional learning. It was hypothesized that the experimental group would obtain higher posttest number-concept scores than the control group.

METHOD

Research Design and Participants

This study used a quantitative quasi-experimental nonequivalent control-group design. The design incorporated pretest and posttest measurement for an experimental group and a control group, allowing descriptive examination of change over time together with a between-group posttest comparison. It was conducted at Raudhatul Jannah Kindergarten and involved

30 children aged 5–6 years, with 15 children in the experimental group and 15 in the control group. The source manuscript states that random sampling was used to select participants, but it does not document random assignment to experimental conditions or clarify whether the groups were intact classes. For that reason, the present revision conservatively reports the groups as nonequivalent rather than randomized. This distinction is methodologically important because sampling and assignment are separate processes: random selection from an eligible population does not, by itself, establish that participants were randomly allocated to treatment conditions. Consequently, causal interpretation must remain qualified and baseline similarity is described only to the extent supported by the available pretest means.

Intervention and Comparison Condition

The independent variable was unplugged coding learning. At the conceptual level, unplugged coding refers to device-free learning activities that represent computational ideas through concrete materials, movement, symbols, patterns, ordered directions, routes, and rule-based problem solving. This conceptualization is consistent with early-childhood unplugged approaches described by Lee and Jo (2019), Saxena et al. (2020), and Chen et al. (2023). In the present study, the experimental condition was intended to engage children in ordered actions, pattern recognition, symbolic directions, and problem solving without relying on computers or tablets. The control group received conventional learning. The source manuscript, however, does not provide a session-by-session intervention protocol or sufficiently detailed description of the comparison condition. Accordingly, this revision does not infer the duration, frequency, dosage, specific games, teaching materials, teacher behaviors, or implementation fidelity beyond what was documented.

This reporting limitation matters because unplugged coding is not a single standardized intervention. Prior research has used substantially different configurations, ranging from floor-grid games and card-based commands to guided play, tangible robotics preparation, and combinations of plugged and unplugged tasks (Critten et al., 2022; Lee & Jo, 2019; Saxena et al., 2020). Learning effects can therefore depend on whether the activity explicitly emphasizes sequencing, whether symbols are mapped consistently to actions, the extent of adult scaffolding, the amount of practice, and whether the comparison group receives an equally intensive alternative. For reproducibility, the final manuscript should specify the operational treatment rather than rely only on the broad label “unplugged coding.”

Outcome Measure

The dependent variable was number-concept understanding. According to the source manuscript, the outcome was assessed using an observation sheet organized around three domains: number recognition, number sequencing, and matching the number of objects with number symbols. These domains are substantively aligned with early-numeracy competencies involving numeral identification, stable order, one-to-one correspondence, and symbol–quantity mapping that are emphasized in developmental mathematics research (Jordan et al., 2006; Nguyen et al., 2016). The same outcome domains were used at pretest and posttest. Earlier categorical descriptions such as “Very high” and “Low” are not retained in the revised results because the source manuscript did not provide the cut-off values or scoring rubric needed to interpret those categories transparently.

For an observational measure, psychometric and procedural information is necessary to establish what the reported scores represent. At minimum, readers need the number of items, response scale, possible score range, scoring rules, source or development procedure, evidence of content or construct validity, reliability information, observer training, and procedures used to reduce rater subjectivity. If more than one observer contributed scores, inter-rater agreement should also be reported. None of these details can be reconstructed

responsibly from the available revision file, so no reliability coefficient or validity claim has been inserted.

Procedure

The study procedure comprised three documented stages. First, both groups completed a pretest to establish their initial number-concept performance. Second, the experimental group received unplugged coding learning while the control group received conventional learning. Third, both groups completed a posttest using the same outcome domains. The procedural logic is illustrated in Figure 1. Because the groups were nonequivalent, the pretest is important for describing initial performance; however, similar group means alone do not demonstrate equivalence on measured or unmeasured characteristics. The procedure therefore supports a preliminary comparison of observed outcomes but does not provide the same control over selection bias as a randomized experiment.

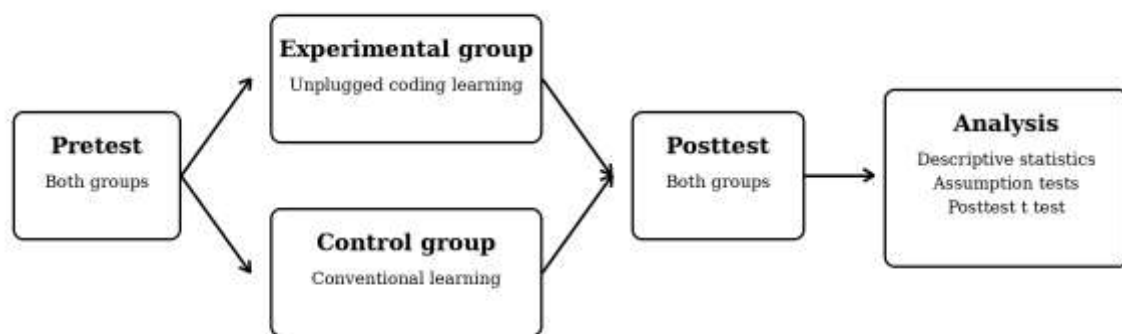


Figure 1. Quasi-experimental study procedure

Statistical Analysis

Descriptive statistics were used to summarize group means at pretest and posttest. Distributional assumptions for the reported posttest analysis were evaluated using the Shapiro–Wilk test, and homogeneity of variance was evaluated using Levene’s test. The original analysis then used an independent-samples *t* test to compare posttest scores between the experimental and control groups with $\alpha = .05$. To strengthen statistical reporting without fabricating unavailable observations, this revision reports the test statistic, degrees of freedom, *p* value, mean difference, a 95% confidence interval for the mean difference, and a small-sample standardized difference. The 95% confidence interval and Hedges’ *g* were derived from the originally reported *t* statistic, mean difference, group sizes, and degrees of freedom. The standardized value is therefore presented explicitly as a derived estimate rather than as a statistic directly produced by the original analysis.

A baseline-adjusted analysis would ordinarily provide stronger evidence in a nonequivalent pretest–posttest design because it incorporates information on initial scores when estimating the group difference. The reviewer recommended an approach such as analysis of covariance or a group-by-time model. Participant-level data and pretest dispersion statistics were not available in the revision source, so such a reanalysis cannot be performed without inventing data. The inferential findings below therefore remain a posttest-only comparison and are interpreted accordingly.

Ethical Considerations

Research involving young children requires transparent reporting of institutional permission, parental or guardian consent, age-appropriate child assent where applicable, confidentiality, and data protection. The revision source did not contain ethical approval or

waiver information and did not document the consent, assent, anonymization, or data-storage procedures. Because these are study-specific facts, they cannot be supplied from external literature or inferred from standard practice.

RESULTS AND DISCUSSION

Descriptive Results

The pretest means were descriptively close: 18.27 in the experimental group and 19.00 in the control group. These means provide useful context but do not, by themselves, establish statistical baseline equivalence because pretest standard deviations and a baseline-adjusted inferential analysis were not reported. At posttest, the experimental-group mean was 31.93, whereas the control-group mean was 20.67. The observed mean increase was therefore 13.66 points for the experimental group and 1.67 points for the control group. As summarized in Table 1, the descriptive pattern indicates substantially greater improvement in the experimental group across the reported measurement period.

Table 1. Descriptive pretest and posttest scores by group

Group	n	Pretest mean	Posttest mean	Observed mean change
Experimental	15	18.27	31.93	13.66
Control	15	19.00	20.67	1.67

Assumption Tests

The reported Shapiro–Wilk tests were nonsignificant for the experimental group, $W = .952$, $p = .554$, and the control group, $W = .918$, $p = .180$. At $\alpha = .05$, these results provide no evidence against the normality assumption for the reported posttest scores. Because each group contained only 15 children, the nonsignificant tests should not be interpreted as proof that the distributions were perfectly normal; rather, they indicate that no statistically detectable departure was reported with the available sample. The reported values are presented in Table 2.

Table 2. Shapiro–Wilk normality tests for posttest scores

Group	W	df	p
Experimental	.952	15	.554
Control	.918	15	.180

Levene’s test of homogeneity of variance was also nonsignificant, $F = .649$, $p = .427$. The equal-variance assumption was therefore not rejected for the reported posttest comparison, and the equal-variance form of the independent-samples t test was retained. Table 3 presents the assumption test.

Table 3. Levene’s test of homogeneity of variance

Outcome	F	p	Interpretation
Posttest number-concept score	.649	.427	Equal-variance assumption not rejected

Between-Group Posttest Comparison

The independent-samples *t* test indicated a statistically significant posttest difference between groups, $t(28) = 12.093$, $p < .001$. The reported mean difference was 11.267 points in favor of the experimental group. Based on the reported *t* statistic and mean difference, the approximate 95% confidence interval for the difference was [9.36, 13.18]. The derived standardized difference was also very large, Hedges' $g = 4.30$. The complete reported and derived statistics are summarized in Table 4. The original table displayed $p = .001$, whereas a *t* value of 12.093 with 28 degrees of freedom corresponds to $p < .001$; the revised manuscript therefore uses $p < .001$ consistently.

Table 4. Independent-samples *t* test for posttest scores

Levene F	Levene p	<i>t</i>	df	<i>p</i> (two-tailed)	Mean difference	95% CI for difference	Hedges' <i>g</i>
.649	.427	12.093	28	< .001	11.267	[9.36, 13.18]	4.30

Discussion

The central finding is a large observed posttest difference in number-concept understanding between the experimental and control groups. The experimental-group mean increased from 18.27 to 31.93, whereas the control-group mean increased from 19.00 to 20.67. Within this sample, the posttest comparison strongly favored children who received unplugged coding learning. The result is consistent with the study hypothesis and suggests that a structured, device-free coding experience may be associated with number-concept learning. At the same time, the magnitude of the observed difference should not be separated from the design conditions under which it was obtained. With only 15 children per group, one kindergarten, no documented random assignment, and a posttest-only inferential comparison, the evidence is best interpreted as a strong signal requiring replication rather than as a definitive causal estimate.

The finding is educationally meaningful because number-concept understanding is not an isolated preschool skill. Early number knowledge is linked to later mathematics development, and longitudinal evidence has consistently identified early mathematics as a major predictor of subsequent achievement (Duncan et al., 2007; Jordan et al., 2006; Nguyen et al., 2016). In this study, the assessed domains—number recognition, sequencing, and quantity—symbol matching—represent foundational relations that support later work with counting and operations. Clements and Sarama's (2004, 2011) learning-trajectory perspective suggests that these relations develop through experiences that connect children's current conceptions to progressively more formal representations. Unplugged coding can potentially contribute to this progression when children coordinate concrete actions with symbols and ordered rules.

Sequencing provides the most direct theoretical link between the intervention and the measured outcome. Coding tasks require children to anticipate what happens first, next, and last, and to understand that changing the order of instructions changes the resulting action. Number sequencing similarly requires stable ordered relations among numerical symbols. Evidence from previous research supports this overlap. Kazakoff et al. (2013) found gains in sequencing following an early-childhood robotics and programming workshop, while Gerosa et al. (2021) reported that computational-thinking performance at age five was related to temporal sequencing and symbolic number comparison. Yang et al. (2023) also identified a positive association between computational thinking and sequencing ability in young children. The present result extends this line of evidence by examining number-concept understanding

as the outcome rather than computational thinking itself, although the current study did not measure sequencing as a mediator and therefore cannot establish the mechanism statistically.

Symbolic mapping offers a second plausible mechanism. In early numeracy, children must connect abstract numerals to quantities; in coding, they must connect arrows, directional symbols, commands, or patterns to actions and outcomes. Bers (2019) conceptualized coding as a representational language that young children can learn through developmentally appropriate experiences. Research with early robotics and coding likewise demonstrates that children can learn to interpret and construct symbolic sequences when interfaces and pedagogy are appropriately designed (Bers et al., 2014; Sullivan & Bers, 2016). Fessakis et al. (2013) further showed that children aged 5–6 years can engage in problem solving within a programming environment, while Papadakis et al. (2016) and Pila et al. (2019) reported learning of foundational programming concepts using child-oriented digital environments. Although those studies used different technologies, they support the broader proposition that young children can coordinate symbols, order, and goal-directed action.

The physical and play-based character of unplugged coding may also be relevant. Rather than requiring a child to manipulate abstract commands only on a screen, unplugged activities can make order and correspondence visible through cards, paths, objects, and body movements. Saxena et al. (2020) explicitly designed unplugged preschool activities around pattern recognition, sequencing, and algorithm design, and Lee and Jo (2019) demonstrated classroom implementation of unplugged coding in early childhood. Critten et al. (2022) similarly showed that guided play can support preschool children's emerging programming and computational-thinking concepts. This embodied dimension is consistent with Mavilidi et al. (2018), who found that task-relevant physical activity enhanced preschool numeracy learning. The studies differ in content and design, but together they suggest that movement and concrete representation can be productive when they are directly aligned with the concept being learned.

The result also aligns with broader syntheses of unplugged and early-childhood computational-thinking research. Chen et al. (2023) found an overall positive effect of unplugged activities on computational-thinking outcomes, while Su and Yang (2023) concluded that age-appropriate computational-thinking education can support both computational knowledge and related skills. Brackmann et al. (2017), although working with primary-school learners rather than preschoolers, showed that unplugged activities can develop computational-thinking skills without reliance on programming software. In the Indonesian context, Mutoharoh et al. (2021), Fitriyah et al. (2023), and Oktaviani et al. (2025) provide additional evidence that unplugged coding can be implemented in ways compatible with early-childhood learning. Damayanti et al. (2026) further noted the relevance of unplugged approaches in contexts where technological resources may be limited. The present study contributes a different outcome focus by directing attention to early number concepts.

That contribution should nevertheless be stated carefully. The study does not demonstrate that computational thinking itself caused the number-concept difference, because computational thinking was not measured. Nor does it show that all forms of unplugged coding will produce comparable effects. The term encompasses interventions that vary substantially in duration, teacher guidance, materials, task complexity, and explicit connection to mathematics. Çakır et al. (2021), for example, reported benefits of a robotics-based coding intervention for problem solving and creative thinking, whereas other studies have used unplugged floor activities, tablet applications, tangible robots, or programming environments. Such heterogeneity means that the pedagogically active ingredient cannot be identified from the label “coding” alone. In the current study, the exact treatment protocol must be documented before the result can be replicated or attributed to particular activity components.

The very large standardized difference also warrants caution. Hedges' $g = 4.30$ is much larger than effects commonly encountered in educational intervention research. A large observed effect may reflect a genuinely strong treatment contrast, especially if the intervention is closely aligned with the outcome measure, but it may also be inflated by small samples, sampling variability, classroom effects, measurement characteristics, baseline imbalance not visible in the means, or differences in implementation intensity. The current effect estimate was derived from the reported t statistic and group sizes rather than calculated from participant-level data. It should therefore be treated as descriptive evidence of a pronounced standardized separation in this sample, not as a stable population parameter. Replication with larger samples and transparent scoring procedures is essential before making claims about expected effect magnitude.

From a practical perspective, unplugged coding may offer several advantages for early-childhood classrooms. It can be implemented without requiring every child to have access to a screen or specialized software, and it can be embedded within play, movement, storytelling, and early mathematics routines. Teachers might use direction cards, floor paths, object sequences, or symbol-to-action games to create opportunities for children to predict, order, match, count, and explain. However, these applications should be intentionally linked to learning objectives. A coding game that emphasizes only following directions may not automatically strengthen number concepts; the activity needs explicit opportunities to coordinate order, quantity, and numerical symbols. The literature on early computational thinking consistently indicates that developmentally appropriate scaffolding and instructional design matter (Bers, 2019; Critten et al., 2022; Su & Yang, 2023).

For teachers and curriculum developers, the most defensible implication is therefore to view unplugged coding as a potentially useful pedagogical structure rather than as a universal replacement for established early-numeracy instruction. It can complement number games, manipulatives, counting routines, pattern work, and other evidence-informed early mathematics experiences. The findings are particularly relevant in settings where digital-device access is constrained or where educators want to preserve active, social, and play-based learning while introducing computational ideas. Yet implementation should be accompanied by clear learning goals, teacher guidance, appropriate progression in task difficulty, and observation of children's mathematical reasoning rather than only task completion.

Future research should strengthen both causal inference and explanatory power. A larger multisite study could reduce dependence on a single classroom context and provide a more stable estimate of the association. Clearly documented allocation procedures would help distinguish treatment effects from selection effects. A validated number-concept measure with reported reliability and inter-rater agreement would improve confidence in the outcome. Baseline-adjusted analysis, such as ANCOVA or a group-by-time model, would use the pretest more effectively than a posttest-only comparison. Intervention-fidelity measures would clarify whether the planned activities were delivered consistently. Finally, measuring candidate mediators—particularly sequencing, pattern recognition, symbolic mapping, and computational thinking—would allow researchers to test why an unplugged coding intervention might influence number-concept learning rather than merely whether the groups differ.

Limitations

Several limitations define the boundaries of the conclusions. First, the design used nonequivalent groups and random assignment was not documented, leaving a risk of selection bias and unmeasured baseline differences. Second, the sample was small ($n = 30$) and drawn from a single kindergarten, limiting external validity and the stability of the unusually large

standardized difference. Third, the intervention dosage, activity sequence, comparison-condition content, teacher role, and implementation fidelity were not reported sufficiently for replication. Fourth, the observation instrument was described only through three indicator domains; item-level scoring, possible score range, validity, reliability, observer training, and inter-rater agreement were unavailable. Fifth, the inferential analysis compared posttest means without explicitly adjusting for pretest scores, and participant-level data were unavailable for reanalysis. Sixth, the study did not directly measure computational thinking, sequencing, pattern recognition, or other hypothesized mediators, so the proposed mechanisms remain theoretical. Finally, ethical approval or waiver, consent, child-assent, confidentiality, data-governance, and statistical-software details must be completed by the authors before publication. These limitations mean that the findings should be interpreted as preliminary evidence from one setting rather than as a definitive estimate of the causal effectiveness of unplugged coding.

CONCLUSION

Children in the unplugged coding group obtained substantially higher posttest number-concept scores than children in the control group in this small quasi-experimental study. The experimental group increased from a mean of 18.27 to 31.93, while the control group increased from 19.00 to 20.67, and the reported posttest difference was statistically significant, $t(28) = 12.093$, $p < .001$. The pattern is theoretically consistent with early-learning research showing that young children benefit from concrete, developmentally sequenced experiences and with computational-thinking research linking coding-related activity to sequencing, symbolic representation, and problem solving. The study's specific contribution is to direct attention from computational-thinking outcomes toward number recognition, number sequencing, and quantity-symbol matching as early-numeracy outcomes of unplugged coding. However, broad causal effectiveness is not established because group assignment was nonequivalent, the sample was limited to one kindergarten, the intervention and instrument require fuller reporting, and the analysis did not explicitly adjust for baseline scores. Unplugged coding should therefore be regarded as a promising, play-based complement to early-numeracy instruction that warrants rigorous replication. Future studies should use larger multisite samples, validated measures, clearly specified and fidelity-checked interventions, transparent ethical procedures, and baseline-adjusted or longitudinal analyses, while also measuring sequencing and computational thinking to test the mechanisms through which coding-related activities may support children's number-concept development.

REFERENCES

- Bers, M. U. (2019). Coding as another language: A pedagogical approach for teaching computer science in early childhood. *Journal of Computers in Education*, 6(4), 499–528. <https://doi.org/10.1007/s40692-019-00147-3>
- Bers, M. U., Flannery, L. P., Kazakoff, E. R., & Sullivan, A. (2014). Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers & Education*, 72, 145–157. <https://doi.org/10.1016/j.compedu.2013.10.020>
- 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. In *Proceedings of the 12th Workshop on Primary and Secondary Computing Education* (pp. 65–72). Association for Computing Machinery. <https://doi.org/10.1145/3137065.3137069>
- Chen, P., Yang, D., Metwally, A. H. S., Lavonen, J., & Wang, X. (2023). Fostering computational thinking through unplugged activities: A systematic literature review and

- meta-analysis. *International Journal of STEM Education*, 10, Article 47.
<https://doi.org/10.1186/s40594-023-00434-7>
- Clements, D. H., & Sarama, J. (2004). Learning trajectories in mathematics education. *Mathematical Thinking and Learning*, 6(2), 81–89.
https://doi.org/10.1207/s15327833mtl0602_1
- Clements, D. H., & Sarama, J. (2011). Early childhood mathematics intervention. *Science*, 333(6045), 968–970. <https://doi.org/10.1126/science.1204537>
- Critten, V., Hagon, H., & Messer, D. (2022). Can pre-school children learn programming and coding through guided play activities? A case study in computational thinking. *Early Childhood Education Journal*, 50, 969–981. <https://doi.org/10.1007/s10643-021-01236-8>
- Çakır, R., Korkmaz, Ö., İdil, Ö., & Uğur Erdoğan, F. (2021). The effect of robotic coding education on preschoolers' problem solving and creative thinking skills. *Thinking Skills and Creativity*, 40, 100812. <https://doi.org/10.1016/j.tsc.2021.100812>
- Damayanti, A., Bella, A. A. I., Lestari, I. I., & Mayangsari, D. (2026). Plugged and unplugged coding approaches for developing computational thinking in early childhood: A systematic literature review. *Nak-Kanak: Journal of Child Research*, 3(2), 103–114.
<https://doi.org/10.21107/njcr.v3i2.222>
- Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., Pagani, L. S., Feinstein, L., Engel, M., Brooks-Gunn, J., Sexton, H., Duckworth, K., & Japel, C. (2007). School readiness and later achievement. *Developmental Psychology*, 43(6), 1428–1446. <https://doi.org/10.1037/0012-1649.43.6.1428>
- Fessakis, G., Gouli, E., & Mavroudi, E. (2013). Problem solving by 5–6 years old kindergarten children in a computer programming environment: A case study. *Computers & Education*, 63, 87–97. <https://doi.org/10.1016/j.compedu.2012.11.016>
- Fitriyah, Q. F., Saputri, L. R., & Aljawad, H. I. (2023). Praktik unplugged coding berbasis daily lives dalam meningkatkan computational thinking pada anak usia dini. *Jurnal Pendidikan Anak*, 12(2), 176–185. <https://doi.org/10.21831/jpa.v12i2.57349>
- Gerosa, A., Koleszar, V., Tejera, G., Gómez-Sena, L., & Carboni, A. (2021). Cognitive abilities and computational thinking at age 5: Evidence for associations to sequencing and symbolic number comparison. *Computers and Education Open*, 2, 100043.
<https://doi.org/10.1016/j.cao.2021.100043>
- 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>
- Haryono, P., Judijanto, L., Maidartati, M., Heriani, D., & Aryanti, N. (2024). *Dasar-dasar pendidikan usia dini: Konsep, teori & perkembangan*. PT Green Pustaka Indonesia.
- Ilyas, S. N., & Alriani, I. (2021). Penggunaan media kartu angka untuk pengembangan kognitif anak usia 5–6 tahun di TK Fath Kab. Majalengka Jawa Barat. *Jurnal Pemikiran dan Pengembangan Pembelajaran*, 3(4), 50–55.
- Jordan, N. C., Kaplan, D., Nabors Oláh, L., & Locuniak, M. N. (2006). Number sense growth in kindergarten: A longitudinal investigation of children at risk for mathematics difficulties. *Child Development*, 77(1), 153–175. <https://doi.org/10.1111/j.1467-8624.2006.00862.x>
- Kazakoff, E. R., Sullivan, A., & Bers, M. U. (2013). The effect of a classroom-based intensive robotics and programming workshop on sequencing ability in early childhood. *Early Childhood Education Journal*, 41(4), 245–255. <https://doi.org/10.1007/s10643-012-0554-5>

- Lee, J., & Jo, J. (2019). Implementing unplugged coding activities in an early childhood classroom setting. *Early Childhood Education Journal*, 47, 709–716. <https://doi.org/10.1007/s10643-019-00967-z>
- Mavilidi, M.-F., Okely, A. D., Chandler, P., Domazet, S. L., & Paas, F. (2018). Immediate and delayed effects of integrating physical activity into preschool children's learning of numeracy skills. *Journal of Experimental Child Psychology*, 166, 502–519. <https://doi.org/10.1016/j.jecp.2017.09.009>
- Mutoharoh, Hufad, A., Faturrohman, M., & Rusdiyani, I. (2021). Unplugged coding activities for early childhood problem-solving skills. *JPUD - Jurnal Pendidikan Usia Dini*, 15(1), 121–140. <https://doi.org/10.21009/JPUD.151.07>
- Nainggolan, A. M., & Daeli, A. (2021). Analisis teori perkembangan kognitif Jean Piaget dan implikasinya bagi pembelajaran. *Journal of Psychology Humanlight*, 2(1), 31–47.
- Nguyen, T., Watts, T. W., Duncan, G. J., Clements, D. H., Sarama, J. S., Wolfe, C., & Spitler, M. E. (2016). Which preschool mathematics competencies are most predictive of fifth grade achievement? *Early Childhood Research Quarterly*, 36, 550–560. <https://doi.org/10.1016/j.ecresq.2016.02.003>
- Oktaviani, P., Diana, D., Waluyo, E., & Formen, A. (2025). Unplugged coding to develop computational and collaborative thinking in early childhood education. *JPUD - Jurnal Pendidikan Usia Dini*, 19(2), 228–235. <https://doi.org/10.21009/jpud.v19i2.57818>
- Papadakis, S., Kalogiannakis, M., & Zaranis, N. (2016). Developing fundamental programming concepts and computational thinking with ScratchJr in preschool education: A case study. *International Journal of Mobile Learning and Organisation*, 10(3), 187–202. <https://doi.org/10.1504/IJMLO.2016.077867>
- Pila, S., Aladé, F., Sheehan, K. J., Lauricella, A. R., & Wartella, E. A. (2019). Learning to code via tablet applications: An evaluation of Daisy the Dinosaur and Kodable as learning tools for young children. *Computers & Education*, 128, 52–62. <https://doi.org/10.1016/j.compedu.2018.09.006>
- Relkin, E., de Ruiter, L., & Bers, M. U. (2020). TechCheck: Development and validation of an unplugged assessment of computational thinking in early childhood education. *Journal of Science Education and Technology*, 29(4), 482–498. <https://doi.org/10.1007/s10956-020-09831-x>
- Saxena, A., Lo, C. K., Hew, K. F., & Wong, G. K. W. (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>
- Su, J., & Yang, W. (2023). A systematic review of integrating computational thinking in early childhood education. *Computers and Education Open*, 4, 100122. <https://doi.org/10.1016/j.caeo.2023.100122>
- Sullivan, A., & Bers, M. U. (2016). Robotics in the early childhood classroom: Learning outcomes from an 8-week robotics curriculum in pre-kindergarten through second grade. *International Journal of Technology and Design Education*, 26(1), 3–20. <https://doi.org/10.1007/s10798-015-9304-5>
- Yang, W., Gao, H., Jiang, Y., & Li, H. (2023). Beyond computing: Computational thinking is associated with sequencing ability and self-regulation among Chinese young children. *Early Childhood Research Quarterly*, 64, 324–330. <https://doi.org/10.1016/j.ecresq.2023.04.006>
- Yüceliyigit, S. (2023). Coding practices in early childhood classrooms: A phenomenological study with ECE teachers in Turkey. *Issues in Educational Research*, 33(3), 1250–1270.