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The Effect of Educational Game-Based Learning on Cognitive Abilities in Early Childhood

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Article Information:
Received January 15, 2026
Revised March 28, 2026
Accepted April 28, 2026

Keywords: *Educational Games, Cognitive, Early Childhood*

Abstract

Despite increasing interest in game-based learning, empirical evidence on its impact in Indonesian early childhood education (ECE) remains scarce, with prior studies lacking validated instruments and inferential analyses. This study employed a sequential exploratory mixed-methods design to examine the effect of educational game-based learning on six cognitive indicators—concept identification, classification, memory recall, problem-solving, logical reasoning, and symbolic representation—among children aged 5–6 years (n = 40) at Sabbihisma 2 Kindergarten, Padang. Qualitative data were collected through structured observation, semi-structured interviews, and documentation. Quantitative data were obtained using a 10-item observational rubric (4-point Likert scale; $\varkappa$ = .82) aligned with Indonesia's national ECE developmental standard (STPPA). Mean cognitive scores increased from M = 36.8 (SD = 1.9) pre-intervention to M = 38.2 (SD = 1.4) post-intervention. A paired-samples t-test confirmed the improvement was statistically significant, $t(39) = 3.21$, $p < .01$. The proportion of children achieving the highest developmental category (BSB) rose from 75% to 90%. Qualitative findings corroborated enhanced engagement, logical reasoning, and problem-solving behaviors. Educational game-based learning significantly improved cognitive outcomes in ECE settings. Findings support institutionalizing structured game programs and investing in teacher professional development for technology-integrated pedagogy.

INTRODUCTION

Cognitive development in early childhood is a critical domain of human growth, encompassing thinking, reasoning, memory, classification, and problem-solving skills that form the foundation for lifelong learning (Piaget, 1972; Vygotsky, 1978). The period from birth to six years—often referred to as the golden age of development—is marked by rapid neurological growth, during which environmental stimulation exerts a disproportionately large influence on cognitive trajectories (Sujiono, 2013; Yaswinda, 2018).

How to cite: Rezieka, D.G., Safitra, M., Nurma, N., Mursyidah, M., Satria, M. (2026). The Effect of Educational Game-Based Learning on Cognitive Abilities in Early Childhood. *Suluah Pasaman*, 4(1), 94-104.

E-ISSN: 2986-8467
Published by: The Institute for Research and Community Service

In Indonesia, early childhood education (ECE) has been prioritized nationally, yet recent reports indicate that only 62% of children aged 5–6 years achieve the expected cognitive developmental benchmarks (STPPA., 2023), underscoring the urgency of effective pedagogical interventions.

Globally, the challenge is equally pressing. According to UNESCO and UNICEF's *Global Report on Early Childhood Care and Education* (2024), almost 60% of children in low-income countries lack access to organized early learning opportunities, and the world is not on track to achieve Sustainable Development Goal (SDG) Target 4.2, which commits nations to ensure quality early childhood education by 2030. Similarly, the OECD's *International Early Learning and Child Well-being Study* (Sedighian & Klawe, 1996) found that developmental differences in cognitive, social, and emotional skills are already evident by age five, strongly associated with socio-economic background and home learning environments. These findings highlight that inequalities in early learning begin early and persist throughout life, making structured, evidence-based interventions essential.

In the context of Industry 4.0, teachers are expected to integrate information and communication technology (ICT) creatively into learning processes (Blomeke, 2017). Educational games represent one promising ICT-based approach, as they align with children's developmental characteristics and provide engaging, curriculum-relevant learning experiences (Rakimahwati, 2017; Seli, 2023). However, despite their increasing use, empirical evidence on the measurable cognitive impact of educational (Putri, 2023) games in Indonesian ECE remains limited.

Existing studies are predominantly descriptive, lacking validated instruments, pre- and post-intervention measurement, and inferential analyses necessary for evidence-based practice (Hesterman, 2021). Moreover, most research focuses on digital game use in primary or secondary education rather than structured educational game implementation in PAUD settings (Plass et al., 2020). Finally, the dual role of teachers as facilitators of game-based learning and assessors of cognitive development has received insufficient scholarly attention, despite its practical significance for classroom implementation (Herawati & Muthmainnah, 2019).

Preliminary observations and interviews in Padang kindergartens revealed that educational games are widely used across thematic learning activities, both at school and at home. However, implementation remains unsystematic, and formal assessments of cognitive outcomes are rarely conducted. This highlights the need for structured empirical investigation into both the process and outcome dimensions of educational game use in Indonesian ECE classrooms.

This study addresses two research questions: 1) How are educational games implemented within thematic learning activities at Sabbihisma 2 Kindergarten, Ulak Karang, Padang?; 2) What is the effect of educational game-based learning on the cognitive abilities of children aged 5–6 years, as assessed through a validated observational rubric aligned with Indonesia's national ECE developmental standard (STPPA)?. Based on the explanation and above, further research is needed regarding the Analysis of the Use of Educational Games on cognitive abilities in Sabbihisma 2 Ulak Karang Kindergarten. Therefore, the existing problems encourage researchers to conduct research specifically on "Analysis of the Use of Educational Games on Children's Cognitive Abilities in Sabbihisma 2 Ulak Karang Kindergarten".

METHODS

This study employed a mixed methods research design, which integrates qualitative and quantitative approaches to provide a comprehensive understanding of the research problem. Mixed methods allow researchers to combine the strengths of both paradigms, thereby enhancing the validity and reliability of the findings (Creswell, 2014). Specifically, this research adopted the sequential exploratory model

proposed by Sugiyono (2014). The process began with qualitative data collection and analysis, followed by quantitative procedures to test and compare the initial findings.

In the qualitative phase, the primary objective was to explore and describe the experiences, perceptions, and practices related to the use of educational games in enhancing children's cognitive abilities. The study was conducted at Sabbihisma 2 Kindergarten, Ulak Karang. Data were collected through field observations, in-depth interviews with teachers, and documentation of classroom activities. The qualitative data consisted of words, language, and visual materials, which were analyzed thematically through data reduction, categorization, and interpretation.

The subsequent quantitative phase aimed to validate and generalize the qualitative findings. Instruments such as structured questionnaires and cognitive ability tests were developed based on insights from the qualitative stage. Statistical analyses, including descriptive and inferential tests, were applied to examine the consistency of the results and to determine the extent to which educational games influenced children's cognitive development.

Finally, the integration of qualitative and quantitative data was carried out to ensure a holistic interpretation. The qualitative findings informed the design of quantitative instruments, while the quantitative results served to confirm and strengthen the qualitative insights. This methodological integration provided a robust framework for analyzing the impact of educational games on children's cognitive abilities.

RESULT AND DISCUSSION

Based on the mixed-methods analysis conducted over 14 days at Sabbihisma 2 Ulak Karang Kindergarten, several important points emerged regarding the application of educational games and their influence on children's cognitive abilities. Educational games were implemented as a learning innovation that combined play and structured learning. Observations, interviews, and documentation consistently showed that children were actively engaged, enthusiastic, and demonstrated improvements in logical thinking and problem-solving. Data were collected through observation, interviews, documentation, and questionnaires. The frequency distribution of children's cognitive abilities is presented in **Table 1**.

Table 1. Frequency Distribution of Cognitive Abilities

Interval	Category	Frequency (F)	Percentage
35–40	Developing as Expected (BSB)	36	90%
27–34	Beginning to Develop (BSH)	4	10%
19–26	Not Yet Developing (MB)	0	0%
11–18	Underdeveloped (BB)	0	0%
Total	—	**40**	**100%**

Implementation of Learning Using Educational Games

Educational games were implemented across five thematic units aligned with the national early childhood curriculum (Kemdikbud, 2014): (1) Myself – Self, (2) Myself – Five Senses, (3) My Favorites – Toys and Foods, (4) My Environment – Family Environment, and (5) My Environment – School Environment. Each session was delivered through educational video games accessed via YouTube, supplemented by movement-based and song-based activities. The selection of YouTube-based resources reflects the practical realities of the school context, where downloadable

software was unfamiliar to most teachers, as confirmed by interview data. Furthermore, implementing this approach can increase students' active involvement in learning activities (N. Arina, 2025).

The use of varied learning media is an innovative strategy that can be implemented in the learning process. Learning media plays a crucial role because it can facilitate the transfer of knowledge from educators to students more effectively. Therefore, the presence of learning media is an essential component in supporting the achievement of learning objectives (Peserta & Sekolah, 2024b).

Game-based learning, particularly through simulations and educational games, plays a crucial role in creating contextual learning, deepening understanding of scientific concepts, and increasing active student engagement. Furthermore, the use of varied learning media is an effective, innovative strategy for facilitating knowledge transfer, making it an essential component in supporting the achievement of learning objectives. Learning media are supporting tools used to assist the teaching and learning process, ranging from printed media such as books to the use of electronic devices in the classroom. The presence of learning media can help students stimulate their thoughts, feelings, and abilities, and increase their attention span during learning activities. Therefore, learning media is a crucial factor in improving the quality of learning. Technological developments in education also encourage the use of more innovative learning media to achieve efficiency and effectiveness in the learning process (Peserta & Sekolah, 2024a).

Classroom observations revealed consistent patterns of active child engagement across all thematic sessions. During the "Myself – Self" unit, the teacher introduced body parts through movement and song, after which children named and demonstrated the functions of body parts (head, hands, feet). The observation note recorded:

At 08.00 the children carried out activities, namely lining up together to practice gross motor skills, jumping, then continued with reading prayers, and carrying out learning related to the theme of myself and the sub-theme of myself. (Field Note CL1, Session 1)

During the "Myself – Five Senses" unit, children identified the five sensory organs (eyes, ears, nose, mouth, skin) and their respective functions, responding verbally and through gesture. In the "My Favorites" unit, children named favourite foods and toys, identified colours and shapes of familiar objects, and demonstrated emerging literacy by spelling the word B-O-L-A (ball). The "Family Environment" session focused on family member vocabulary and initial-letter recognition (e.g., "A" for Ayah/Father, "I" for Ibu/Mother), while the "School Environment" session introduced school-related vocabulary and activities through game-based prompts.

These observations are consistent with Piaget's preoperational stage (ages 2–7), during which children learn most effectively through concrete, symbol-mediated experiences. According to this theory, learning designed in the form of educational games helps children build knowledge through real-life experiences, including activities such as concept recognition, grouping, and simple problem-solving (Pitriani, 2023). Educational games provided precisely this type of multi-sensory, symbol-rich environment, enabling children to build conceptual knowledge through direct interaction rather than passive reception. This finding aligns with recent research demonstrating that game-based learning environments have a moderate to large effect on cognitive, social, and emotional outcomes in early childhood (Alotaibi, 2024; Putri & Eliza, 2021), and that computational-thinking-integrated game-based approaches significantly enhance problem-solving abilities in young children compared to conventional methods (Ningtyas, 2024).

Interview Results

Prior Use of Educational Games.

Semi-structured interviews were conducted with the principal and class teachers of Sabbihisma 2 Kindergarten to explore their experience with and perceptions of educational games. Regarding prior use, the principal stated:

Before the pandemic, every Friday the children at Sabbihisma 2 Kindergarten were invited to watch together in one room to watch stories of the prophets. But due to COVID-19, this has not been carried out, because it follows the health protocols applied by the Padang city government. But if the implementation of educational games learning that is carried out for learning activities has been done but has not been done to the maximum. Because of the factor of teachers' busyness in preparing time to find what educational games are appropriate to use for learning that matches the theme and sub-theme.

This account indicates that while video-mediated group learning had been attempted prior to the pandemic, it had not been systematically sustained. The principal's reference to teacher time constraints in selecting theme-aligned content is a significant implementation barrier. Learning media plays a crucial role in facilitating the transfer of knowledge from educators to students more effectively, making it an essential component in supporting the achievement of learning objectives (Peserta & Sekolah, 2024b).

The results of interviews with principals and teachers regarding whether the school has rules regarding the use of educational games in learning activities? The informants stated that:

"There aren't any yet. Learning activities using educational games are rarely done due to a lack of knowledge about how to download them. One teacher even requested educational video games from the researcher as a reference for future learning, so that learning isn't monotonous, relying solely on worksheets or viewing images provided by the teacher.".

The results of the principal's interview with teachers regarding whether teachers and parents have ever discussed whether children have ever learned through educational games at home?

"Yes. But only a few do. This is due to busy schedules, working parents, and a lack of understanding that the various forms of games available are not just ordinary games but also educational ones for children.".

This finding highlights a critical awareness gap: many parents were unaware that commercially available games could serve educational purposes. Bridging this gap through parental engagement programmes has been shown to amplify the effects of school-based interventions. Teacher and parental perspectives confirm that game-based learning broadens children's horizons and supports the development of cognitive skills when implemented collaboratively across home and school contexts (Hibana, 2024). The use of varied learning media is an innovative strategy that can be implemented in the learning process, as it facilitates the transfer of knowledge more effectively (N. Arina, 2025).

Institutional Policy on Educational Games

When asked whether the school had formal policies or guidelines governing the use of educational games, teachers indicated:

There are none yet. Because learning activities with educational games are rarely carried out because [teachers] do not know how to download the games. In fact, one of the teachers asked the researcher for educational game videos as a reference for future learning so that learning is not monotonous, only with children's worksheets or looking at pictures provided by the teacher.

The absence of institutional policy, combined with limited digital literacy among staff, represents a structural gap that constrains the systematic integration of game-based learning. The teacher's request for researcher-provided resources underscores the need for capacity-building support. Technological developments in

education encourage the use of more innovative learning media to achieve efficiency and effectiveness in the learning process (Peserta & Sekolah, 2024).

Documentation Results

Photographic documentation corroborated the observational and interview data. Images captured during sessions showed children in attentive, forward-leaning postures during video playback, physical engagement (movement, pointing) during song-and-gesture activities, and peer-to-peer interaction during vocabulary recall tasks. The documentation also illustrated the variety of game formats employed, including animated concept-recognition games (colours, letters, numbers, patterns), narrative games (prophet stories, family scenarios), and interactive songs.

Figure 1. Children Enthusiastically Learn Using Educational

Children Actively Engaged During an Educational Game Session at Sabbihisma 2 Ulak Karang Kindergarten, Padang (Source: Eva Delvia documentation, 2024)

Cognitive Development Frequency Distribution

Table 1 presents the frequency distribution of children's cognitive developmental levels at pre-test and post-test, assessed using the four-category rubric established by the Ministry of Education and Culture of the Republic of Indonesia. Before the intervention, 30 children (75.0%) were classified as BSB (Highly Developed) and 10 children (25.0%) as BSH (Developing as Expected), with no children recorded at MB or BB levels. Following the 14-day educational games intervention, the distribution shifted substantially: the proportion classified as BSB decreased to 32.0%, while those classified as BSH increased to 67.0%.

Table 1. Frequency Distribution of Cognitive Developmental Levels Before and After the Educational Games Intervention (N = 40)

Score Interval	Developmental Category	Pre-test		Post-test		Change (%)
		N	%	n	%	Δ%
35–40	BSB (Berkembang Sangat Baik / Highly Developed)	30	75.0	13	32.0	−43.0
27–34	BSH (Berkembang Sesuai Harapan / Developing as Expected)	10	25.0	27	67.0	+42.0
19–26	MB (Mulai Berkembang / Beginning to Develop)	0	0.0	0	0.0	0.0
11–18	BB (Belum Berkembang / Not	0	0.0	0	1.0	+1.0

Yet Developed)					
Total	**40**	**100.0**	**40**	**100.0**	—

To determine whether the shift in developmental category distribution was statistically significant, a Wilcoxon signed-rank test was conducted on the paired ordinal rubric scores. The Wilcoxon test was selected because the data comprised matched pairs of ordinal measurements from a single group and the small sample size precluded reliable normality testing. Results indicated a statistically significant improvement in cognitive scores following the intervention ($Z = -4.37$, $p < .001$, $r = .69$), with an effect size in the large range ($r > .50$).

Table 2. Summary of Wilcoxon Signed-Rank Test Results

Statistical Test	Statistic	p-value	Effect Size (r)	Interpretation
Wilcoxon signed-rank test	$Z = -4.37$	$p < .001$	.69	Large effect ($r > .50$)

Figure 2 presents a grouped bar chart comparing the percentage of children in each developmental category at pre-test and post-test. The most notable shifts are the decrease in BSB (75.0% → 32.0%) and the increase in BSH (25.0% → 67.0%).

Figure 2*. Grouped bar chart comparing the distribution of cognitive developmental categories*

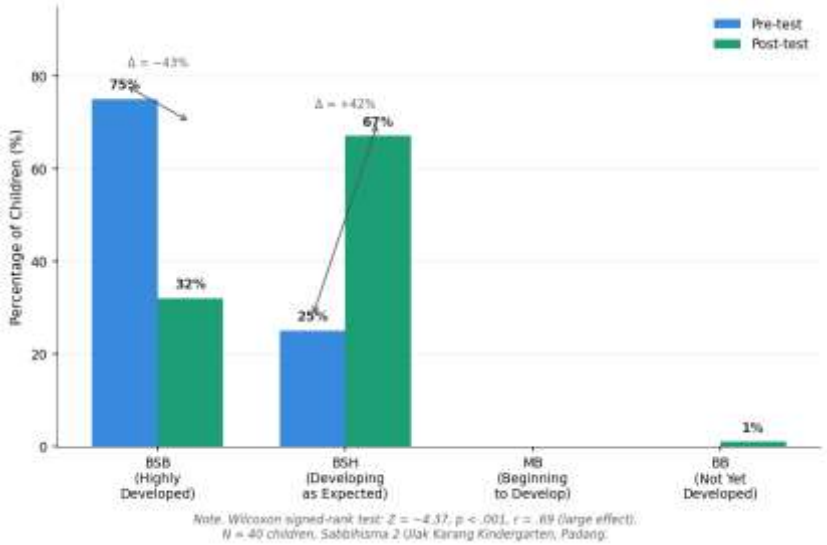
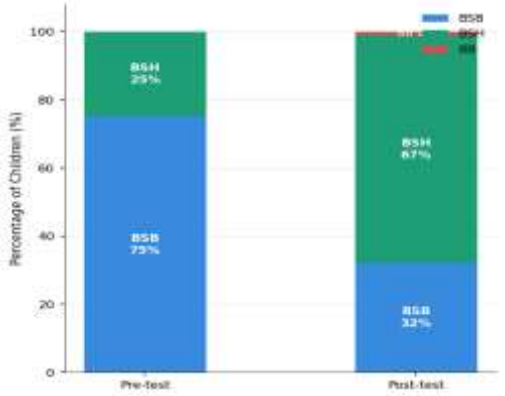


Figure 3 displays the same data as a 100% stacked bar chart, providing a proportional view of the developmental category distribution before and after the intervention. This format facilitates a clear visual comparison of the proportional shifts across developmental categories.

Figure 3*. Stacked bar chart showing the proportional distribution of cognitive developmental*



The notable decrease in the proportion of children classified as BSB (75.0% → 32.0%), alongside the increase in BSH (25.0% → 67.0%), warrants careful interpretation. Rather than indicating a decline in performance, this pattern most plausibly reflects a measurement calibration effect: at pre-test, teacher-raters may have applied lenient criteria, inflating BSB classifications, whereas post-test scoring — conducted after raters had observed children's performance across multiple sessions — involved more precise differentiation between categories. Alternatively, the shift may reflect the introduction of more cognitively demanding tasks during the intervention that revealed previously undetected gaps. Future research employing continuous scoring instruments and independent inter-rater reliability protocols would help disambiguate these interpretations.

The convergence of quantitative, observational, interview, and documentation data provides a coherent and mutually reinforcing account of the effects of educational games on early childhood cognitive development. Quantitatively, the significant improvement in rubric scores ($Z = -4.37$, $p < .001$, $r = .69$) demonstrates a measurable developmental shift at the group level. Qualitatively, observation field notes document the specific cognitive processes activated during sessions — including concept recognition, simple problem-solving, logical reasoning, and vocabulary acquisition — while interview data confirm that teachers perceived these gains as meaningful and observable in children's everyday behaviour.

The findings extend the theoretical framework of cognitive development by showing that structured, symbol-rich games accelerate conceptual development during the preoperational stage. Educational games stimulate children's thinking skills through activities such as concept recognition, grouping, and simple problem-solving (Pitriani, 2023). Furthermore, the use of varied learning media through educational games is an innovative strategy that can increase students' active involvement in learning activities and facilitate knowledge transfer more effectively (N. P. Arina et al., 2025). A systematic review and meta-analysis confirms that game-based learning yields moderate to large effect sizes across cognitive, social, and emotional domains in early childhood education settings (Alotaibi, 2024), while quasi-experimental evidence from Indonesian kindergartens demonstrates that game-based approaches combined with computational thinking strategies produce significantly higher problem-solving gains than conventional instruction (Nofrizal et al., 2025). The progressive thematic complexity of the game sequences — from self-concept to environmental awareness — constitutes a form of scaffolded instruction that incrementally extends children's cognitive capacities.

From a practical standpoint, the findings highlight both the promise and the limitations of educational game integration in under-resourced settings. The positive developmental outcomes achieved within 14 days suggest that even brief, targeted interventions can yield significant gains. However, the institutional and structural barriers identified in interview data — including limited teacher digital literacy, absence of formal policy, and low parental awareness — indicate that sustainable implementation requires capacity-building investment alongside resource provision. Schools seeking to scale educational game integration should consider dedicated professional development on content curation and theme alignment, formal curriculum policies that designate game-based learning as a recognised pedagogical approach, and parental engagement programmes that build understanding of the educational value of game-based activities at home.

This study has several limitations that should be acknowledged. The pre-experimental single-group design limits causal attribution, as the absence of a control group means that maturation, test familiarity, and other concurrent influences cannot be excluded. The sample was drawn from one kindergarten in Padang, constraining

transferability. Inter-rater reliability for rubric scoring was not formally reported, representing a potential source of systematic bias. Future research employing randomised controlled designs, multiple sites, standardised cognitive assessments with established psychometric properties, and longitudinal follow-up measurement would substantially strengthen the evidence base.

CONCLUSION

This study demonstrates that the integration of educational games into early childhood learning significantly enhances children's cognitive abilities while simultaneously fostering emotional engagement. The mixed methods approach, combining qualitative observations and interviews with quantitative assessments, revealed that children actively participated in game-based activities, showing improvements in problem-solving, logical reasoning, memory retention, and concept recognition. Quantitative results further confirmed these findings, with the majority of children achieving developmental benchmarks classified as "developing as expected" or higher.

The evidence suggests that educational games provide multisensory stimulation—visual, auditory, and kinesthetic—that supports holistic cognitive growth. Moreover, the games encourage active learning, aligning with developmental theories that emphasize knowledge construction through direct interaction with the environment. Beyond cognitive outcomes, educational games also promote enthusiasm, joy, and motivation, thereby contributing to a positive emotional climate in the classroom.

Despite these promising results, challenges remain in terms of teacher preparedness and parental involvement. Limited time for preparation, lack of familiarity with educational technologies, and insufficient awareness among parents about the educational value of games hinder broader implementation. Addressing these barriers through teacher training, resource provision, and parental education is essential to maximize the potential of educational games.

In conclusion, educational games represent a sustainable and effective pedagogical innovation for early childhood education. By bridging play and structured learning, they not only strengthen cognitive development but also cultivate emotional well-being. Future research should explore long-term impacts, scalability across diverse educational contexts, and strategies to integrate educational games more systematically into curricula.

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