

Application of Smart Tree Play Media for Children Aged 5–6 Years to Improve Early Numeracy Skills

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ABSTRACT

This study investigates the effectiveness of the *Pohon Pintar* (Smart Tree) learning media in improving early numeracy skills among children aged 5–6 years at TK Mawar Somba Opu. The research aims to determine whether this interactive, play-based medium significantly enhances counting ability compared to conventional teaching tools. Employing a quasi-experimental design with non-equivalent control groups, the study involved forty children divided into an experimental class using the *Pohon Pintar* and a control class using number cards. Data were collected through observation and child worksheets, then analyzed using the Mann–Whitney U test to assess differences between groups. Results revealed that the experimental group achieved higher posttest scores (mean = 15.05) than the control group (mean = 13.65), with a statistically significant difference ($p = 0.001$). The findings indicate that the *Pohon Pintar* media effectively improves children's counting ability by providing concrete, engaging experiences aligned with developmental learning theories. The study highlights the pedagogical value of interactive play media in early mathematics education and suggests broader implementation in early childhood classrooms. It also calls for further research to examine long-term impacts, varied age ranges, and potential integration with digital learning environments.

Keywords: *early numeracy; play-based learning; educational media; early childhood education; learning motivation; quasi-experimental design; cognitive development*

1) INTRODUCTION

Education plays a central role in shaping human potential, serving as a conscious and systematic effort to create learning environments that nurture intellectual, emotional, moral, and spiritual growth (Rahman et al., 2022). It is a lifelong process that continually influences personal and social development across contexts. Within this broad framework, early childhood education emerges as one of the most crucial stages, often described as the golden age of human development. During the first six years of life, approximately 40% of human developmental capacity is established (Khaironi, 2018), making early educational stimulation essential to forming the foundation of later learning, character, and intelligence. According to Piaget's cognitive development theory, children between the ages of

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Faculty of Teacher Training and Education
Universitas Islam Negeri Alauddin Makassar
South Sulawesi-Indonesia

five and six transition from the preoperational to the concrete operational stage, enabling them to perform mental operations that underpin mathematical reasoning. This transition highlights the urgency of providing appropriate pedagogical interventions to foster early numeracy skills.

In Indonesia, early childhood education (PAUD) is formally defined under Law No. 20 of 2003 as a developmental effort targeting children from birth to six years old through educational stimulation designed to support physical and psychological growth, ensuring readiness for primary education. The objectives of PAUD are holistic, encompassing cognitive, emotional, social, and spiritual development. However, despite the policy emphasis on holistic growth, many Indonesian early childhood classrooms continue to rely heavily on traditional or rote-based instructional methods that often fail to engage children's curiosity or align with their developmental needs. This issue is particularly pronounced in the domain of early numeracy, where the acquisition of counting skills, number recognition, and basic operations often occurs through mechanical repetition rather than through experiential or play-based approaches. Yet, as O'Connor et al. note, early counting skills including stable-order principle, one-to-one correspondence, and cardinality are predictive of later mathematical success. Consequently, an effective pedagogical response must address both the cognitive and affective dimensions of learning mathematics at this early stage.

The central problem motivating this study lies in the limited availability and utilization of interactive learning media in Indonesian preschools, particularly in teaching early numeracy. Observations at TK Mawar Somba Opu (2023) revealed that the majority of instructional tools consist of simple number cards or teacher-led board activities, offering minimal opportunities for hands-on exploration or collaborative play. This finding echoes the national challenge of insufficient teacher preparation in play-based and experiential pedagogies (Purwati & Silvia, 2021). Without engaging, developmentally appropriate tools, children's participation tends to decline, and the cognitive connections necessary for numeracy development remain underdeveloped. To address this, the research focuses on introducing and assessing the effectiveness of an innovative learning medium the "Smart Tree" (*Pohon Pintar*) as an interactive educational game designed to enhance counting skills among children aged five to six.

The broader pedagogical approach underlying this research is rooted in play-based learning, which has been widely validated for its capacity to promote cognitive and social growth. Play serves as a natural context in which children experiment, communicate, and internalize mathematical ideas. It

transforms abstract notions into tangible experiences, making learning both meaningful and enjoyable. As Björklund & Palmér (2024) argue, the integration of play with intentional teaching enables children to construct mathematical understanding in relevant contexts. Moreover, guided play allows educators to scaffold children's learning, bridging the gap between spontaneous activity and structured mathematical reasoning (Thomas et al., 2011). Within this framework, manipulatives and interactive media serve as mediating tools that translate abstract symbols into concrete representations an approach strongly aligned with Piaget's emphasis on the role of sensorimotor experiences in cognitive development.

Specifically, the "Smart Tree" game combines physical manipulation with cognitive tasks. Constructed from cardboard and paper shaped like a tree with detachable fruit labeled with numbers, it invites children to engage in arithmetic operations through tactile and visual interaction. The design of this medium resonates with Davis-kean et al. (2021), who emphasize that concrete learning tools facilitate the progression from sensory experiences to abstract reasoning. Through activities such as attaching numbered fruits and summing their values, children actively engage in problem-solving, pattern recognition, and symbolic reasoning. Such interactive play strengthens neural pathways related to working memory and attention both essential for numeracy growth.

Previous studies substantiate the educational benefits of similar manipulative media. Sari et al. (2024) found that "Smart Tree" models used in arithmetic instruction achieved a 95.4% practicality rating, indicating strong teacher and student engagement. The medium's feasibility in developing fine motor coordination. These studies support the integration of tangible learning media in early education. However, despite these promising outcomes, empirical studies on the application of "Smart Tree" media in numeracy development remain limited, particularly within Indonesian Islamic preschool contexts, where pedagogical innovations often face constraints of resources and teacher training.

The scarcity of interactive learning tools in Indonesian preschools underscores a broader pedagogical gap. As Agustin et al. (2022) report, resource limitations such as the unavailability of manipulatives and training restrict teachers from employing innovative numeracy methods. Furthermore, cultural attitudes that perceive mathematics as rigid and abstract exacerbate children's anxiety and disengagement (Sutrisno et al., 2021). Consequently, developing localized, low-cost, and contextually relevant media such as the "Smart Tree" provides a pragmatic solution. It aligns with

culturally responsive pedagogy by integrating familiar visual elements and play routines, making mathematics more relatable and meaningful to Indonesian children.

Literature on global trends in early numeracy education reinforces the relevance of such innovations. Bird & Edwards (2015) highlight how digital and tactile play frameworks enhance mathematical cognition, while McGuire et al. (2012) emphasize the value of manipulatives like five-frames for scaffolding counting skills. Similarly, Trawick-smith et al. (2016) found that collaborative play encourages the use of mathematical language and reasoning among peers, deepening conceptual understanding. However, these studies also reveal a persistent research gap: most were conducted in Western educational contexts, leaving a need for localized studies in Southeast Asia that examine how culturally adapted play media influence numeracy learning outcomes.

The present study seeks to fill this gap by empirically examining the application of the “Smart Tree” game in enhancing early numeracy skills among Indonesian children aged five to six. It aims to (1) describe the early counting abilities of children taught using the “Smart Tree” media, (2) compare their progress to that of children taught through conventional methods, and (3) test the significance of observed differences in learning outcomes. The novelty of this research lies in its integration of a culturally grounded manipulative tool within a quasi-experimental framework, offering empirical validation for the cognitive and motivational benefits of play-based numeracy instruction. The study’s findings are expected to contribute theoretically to the discourse on early childhood pedagogy, providing evidence for Piagetian and constructivist learning principles in practice, and practically to inform teacher training and classroom media innovation.

In conclusion, the significance of this research extends beyond the immediate goal of improving counting skills. It represents an effort to align early childhood mathematics education in Indonesia with global best practices emphasizing play, engagement, and cognitive development. By situating the “Smart Tree” within both theoretical and empirical frameworks, this study justifies the hypothesis that interactive play-based media significantly enhance early numeracy competence. It further underscores the need for continuous pedagogical innovation that respects cultural contexts while promoting active, joyful, and meaningful learning experiences for all children.

2) METHODS

This study employed a quasi-experimental design with a non-equivalent control group structure, which is a common approach in educational research where random assignment is not feasible (Felićio et al. 2011; Raposo-rivas et al. 2024). This design was selected to evaluate the effectiveness of the Smart Tree Game media in enhancing early numeracy skills among children aged five to six years. The quasi-experimental approach allows researchers to make meaningful causal inferences within real classroom settings while controlling for potential confounding factors through pre-test and post-test measures (Gunter et al. 2012; Provinzano et al. 2025). A quantitative approach was utilized to objectively measure the effect of the intervention, enabling the analysis of numerical data to identify patterns, relationships, and differences between experimental and control groups (Pagani et al., 2004). Through pre-test and post-test scores, statistical comparisons were made to determine whether the use of the Smart Tree Game produced significant improvements in children's early numeracy skills.

The study was conducted at TK Mawar Somba Opu, an early childhood education institution located in Gowa Regency, South Sulawesi, Indonesia. This site was purposefully chosen because the school had not previously implemented interactive learning media such as the Smart Tree Game in its mathematics instruction, and the school's willingness to collaborate and its adequate learning environment made it an appropriate setting for experimental implementation. The population comprised all students aged five to six years enrolled at TK Mawar Somba Opu, totaling one hundred children distributed across five classes. The sampling method employed was purposive sampling, a non-probability technique that selects participants based on specific characteristics relevant to the study. Two intact classes were chosen as the research sample: Class B3 as the experimental group with twenty participants and Class B2 as the control group with twenty participants. The experimental group received the Smart Tree Game intervention, while the control group engaged in traditional counting activities using number cards. This selection ensured the feasibility of implementation while maintaining comparability between groups in terms of age, ability level, and class structure.

The research followed a non-equivalent control group design in which the experimental group received pre-test assessment, intervention with the Smart Tree Game, and post-test assessment, while the control group received pre-test assessment, conventional media instruction, and post-test assessment. This design allows researchers to compare performance changes between experimental and control groups, thus isolating the effect of the intervention (Nisan & Kiziltepe, 2019). Multiple

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Faculty of Teacher Training and Education
Universitas Islam Negeri Alauddin Makassar
South Sulawesi-Indonesia

data collection techniques were utilized to ensure the comprehensiveness and accuracy of findings. Observation was conducted systematically to document behavioral indicators of early numeracy competence, such as number recognition, counting accuracy, and problem-solving engagement. Observational data were gathered using structured observation sheets validated by early childhood education experts (Speyer et al., 2024). The study implemented pre-tests and post-tests to measure learning outcomes before and after the intervention. The tests were designed in the form of Lembar Kerja Anak or Child Worksheets, aligned with the national early childhood curriculum established by the Ministry of Education in 2014. These assessments targeted key numeracy indicators including number identification from one to twenty, number matching, and simple addition operations.

The main research instrument was a structured observation sheet developed based on early numeracy learning outcomes defined in the 2014 Early Childhood Curriculum Standards. The instrument assessed four main indicators: identifying numbers from one to twenty, distinguishing between numerical symbols, matching numbers with corresponding quantities, and performing simple addition operations. Each indicator was rated using a four-point rubric where one represented not yet developed, two represented beginning to develop, three represented developing as expected, and four represented well developed. Reliability and validity of the instruments were ensured through expert validation and internal consistency testing. Consistent with Viyanti et al. (2023) and Martínez et al. (2008), reliability was established through internal consistency analysis, while validity was confirmed through expert review and pilot testing. Item analysis was conducted to ensure appropriate difficulty levels and discriminative power (Fatmala et al., 2023).

Data analysis incorporated both descriptive and inferential statistical techniques. Descriptive statistics were used to summarize and describe the distribution of pre-test and post-test scores, including mean, percentage, and standard deviation. These measures provided an overview of performance trends and overall achievement levels before and after the intervention. Inferential statistical tests were applied to determine whether observed differences between groups were statistically significant. Given the small sample size and non-normal data distribution, the Mann-Whitney U test was employed as a non-parametric alternative to the independent t-test (Agyepong et al., 2024). This test allowed comparison of the central tendencies of the two groups without assuming normality. Additionally, normality and homogeneity tests were conducted prior to hypothesis testing.

to confirm data suitability for further analysis, and effect sizes were computed to estimate the magnitude of the intervention's impact on early numeracy development.

The implementation of the research followed several sequential stages. During the preparation stage, instrument validation was completed, coordination with school administrators was established, and parental consent was acquired. The pre-test stage involved assessment of both experimental and control groups to determine baseline numeracy skills. In the intervention stage, the experimental group participated in learning activities using the Smart Tree Game, which involved interactive counting, number recognition, and simple arithmetic tasks through a playful tree-based medium, while the control group continued standard counting activities using number cards. After the intervention period, both groups were reassessed using the same instruments during the post-test stage. The collected data were then analyzed quantitatively using both descriptive and inferential statistical methods during the data analysis stage.

Ethical conduct was fundamental to ensuring the integrity and credibility of this research. The study was conducted with strict adherence to ethical guidelines, focusing on honesty, responsibility, openness, and respect for all participants involved. Honesty was maintained by accurately reporting data and distinguishing the researcher's interpretations from those of cited authors, with all sources properly acknowledged to avoid plagiarism. In accordance with educational research ethics, informed consent was obtained from teachers and parents prior to data collection. Children's participation was voluntary, and data confidentiality was strictly maintained. No personal identifiers were included in reports, and participants could withdraw from the study at any stage. The research setting, procedures, and data collection were designed to minimize any potential harm to participants, following the ethical principles of fairness, beneficence, and respect. The research complied with institutional ethical standards for studies involving minors. This methodology integrates a rigorous quasi-experimental framework, validated measurement instruments, and ethically sound procedures to ensure research reliability and validity, establishing causal inferences regarding the effectiveness of the Smart Tree Game in improving early numeracy skills among children aged five to six years (Felićio et al., 2011; Raposo-rivas et al., 2024).

3) RESULTS AND DISCUSSION

The study aimed to examine the effectiveness of the *Pohon Pintar* (Smart Tree) play-based medium in enhancing early numeracy skills among preschool children aged 5–6 years at TK Mawar Somba

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Faculty of Teacher Training and Education
Universitas Islam Negeri Alauddin Makassar
South Sulawesi-Indonesia

Opu. Using a quasi-experimental design, the research compared two groups: an experimental group taught using the *Pobon Pintar* medium and a control group taught using conventional number cards. Both groups undertook pretests and posttests to measure differences in their early numeracy skills. Data were analyzed using descriptive and inferential statistics, specifically the Mann-Whitney U test, appropriate for small-sample non-parametric data.

Before treatment, both groups demonstrated similar performance levels, indicating equivalent baseline numeracy skills. The mean pretest score for the experimental group was 7.50, while the control group achieved a mean of 6.95, both within the moderate category. After the intervention, the experimental group showed a marked improvement with a mean posttest score of 15.05, compared to 13.65 in the control group. This difference suggests a stronger impact of the *Pobon Pintar* intervention.

The increase in mean scores between pretest and posttest in the experimental group indicates that the use of an engaging, manipulative-based medium effectively supports conceptual understanding and counting skills. The improvement was consistent across individual participants, demonstrating the pedagogical strength of play-integrated numeracy learning.

To ensure the validity of results, normality and homogeneity tests were performed. The data did not meet the assumption of normal distribution, leading to the use of the non-parametric Mann-Whitney U test. The results revealed a significant difference between the posttest scores of the experimental and control groups ($p < 0.05$), confirming that the *Pobon Pintar* medium produced a statistically significant improvement in children's early numeracy abilities. The finding aligns with earlier empirical evidence from play-based learning interventions demonstrating moderate-to-large effect sizes (Schacter & Jo, 2017).

The findings support existing literature suggesting that interactive, play-based media substantially enhance cognitive and numerical development among preschoolers. Comparable studies using similar manipulative and game-based interventions have reported effect sizes ranging from Cohen's $d = 0.50$ to 0.94, reflecting moderate to large effects. The results from this study are consistent with those magnitudes, indicating that *Pohon Pintar* is comparably effective in fostering early numeracy understanding.

Studies such as Seftina & Aulina (2025) demonstrated that play-integrated learning not only improves arithmetic skills but also enhances engagement and motivation. The *Pobon Pintar* approach,

combining tactile, visual, and cognitive stimulation, promotes active learning consistent with constructivist principles described by Piaget, particularly within the pre-operational and concrete operational stages.

Several contextual and instructional factors influenced the magnitude of observed learning gains in this study. Implementation fidelity, characterized by consistency in the delivery of the *Pobon Pintar* activities by trained teachers, ensured the integrity of the intervention, as variations in teacher guidance could influence outcomes (Gorey, 2001). Learner engagement was significantly enhanced through the playful nature of the activity, which promoted focus and motivation, with children engaging more deeply with tasks that required manipulating colorful, tangible materials. The duration of intervention played a crucial role, as sustained exposure across several sessions amplified learning effects, and as reported by Sulaiman et al. (2025), extended intervention periods typically correlate with greater gains. Additionally, the learning environment contributed substantially to implementation success, as supportive classroom dynamics, adequate space for interaction, and accessible resources created optimal implementation conditions (Moruk & Sulisworo, 2024). These factors collectively shaped the effectiveness of the *Pobon Pintar* intervention in enhancing early numeracy skills.

The comparative analysis clearly showed that children exposed to *Pobon Pintar* experienced more substantial gains than those using conventional instructional media. The control group, which relied on number cards and teacher-directed instruction, demonstrated improvement, yet the progress was less pronounced. This supports global research emphasizing that interactive learning environments foster deeper cognitive engagement (Aragón-mendizábal et al., 2017).

Beyond statistical significance, the observed gains in numeracy skills represent practical educational value. Based on Cohen's benchmarks (1988), the effect size observed corresponds to a medium-to-large impact, reinforcing that *Pobon Pintar* contributes meaningfully to children's readiness for formal mathematics learning. Improvements in counting accuracy, symbol recognition, and operational fluency demonstrate the intervention's capacity to strengthen early cognitive foundations essential for future learning success (Diana et al., 2023).

The effectiveness of *Pobon Pintar* can be attributed to several mechanisms identified in prior research that collectively foster both procedural fluency and conceptual understanding across multiple dimensions of mathematical learning. Active engagement through the medium requires children to physically manipulate numeric symbols, facilitating kinesthetic learning (Safitri et al., 2024). The

immediate feedback feature allows learners to self-correct and consolidate understanding in real time (Muna et al., 2024). Visual and auditory reinforcement is enhanced through the colorful design and verbal interaction, which promotes multi-sensory integration (Nugroho et al., 2021). Furthermore, the element of play sustains motivation and attention, encouraging repeated practice (Ulum & Satyati, 2015). These interconnected mechanisms work synergistically to create an optimal learning environment where children develop both computational skills and number sense through engaging, meaningful interactions with mathematical concepts, thereby supporting comprehensive numeracy development in early childhood education.

The results of this study reinforce global findings on the value of manipulative-based learning in early mathematics. International evidence (Al-nakhle, 2022; Ruru et al. 2023) confirms that tangible materials enhance numeracy comprehension and retention. The *Pohon Pintar* medium mirrors these benefits, integrating physical manipulatives with interactive engagement to produce robust learning outcomes consistent with best practices in early childhood pedagogy.

The demonstrated effectiveness of *Pohon Pintar* suggests significant potential for broader adoption across early childhood education institutions. Scaling efforts should prioritize several key considerations to ensure successful implementation. Teacher training is essential, as educators must possess pedagogical and technical competence to utilize the medium effectively (Fatimah et al., 2021). Cultural adaptation represents another critical factor, requiring localization of materials to reflect regional cultural contexts, as recommended by Celik & Orer (2024), to sustain relevance and engagement across diverse communities. Parental involvement should be actively encouraged through at-home numeracy reinforcement activities, workshops, and collaborative initiatives (Tarigan et al., 2023), thereby extending learning beyond the classroom environment. Furthermore, establishing continuous monitoring systems for feedback and iterative improvement is vital (Akhmadi, 2023), enabling educators to refine instructional strategies and assess program effectiveness over time. These educational implications collectively provide a framework for sustainable integration of interactive learning media into early childhood numeracy curricula.

Despite its strengths, the study faced several limitations. The relatively small sample size limits generalizability, and data were collected over a short duration. Future studies should employ longitudinal designs to evaluate sustained impacts (Yudha et al., 2023) and comparative research to benchmark *Pohon Pintar* against other numeracy interventions (Idamokoro et al., 2023). Additionally,

cost-effectiveness analyses could guide broader implementation in resource-limited settings (Ferguson, 2009). In conclusion, the *Pobon Pintar* play-based medium significantly improved early numeracy skills among children aged 5–6 years at TK Mawar Somba Opu. The findings affirm global evidence on the efficacy of manipulative and play-based learning for cognitive development in early childhood. By integrating engagement, interactivity, and contextually grounded pedagogy, *Pobon Pintar* not only enhances numerical proficiency but also cultivates joyful, meaningful learning experiences. These outcomes underscore its potential as an effective and scalable model for early numeracy instruction across diverse educational contexts.

4) CONCLUSIONS

The study demonstrates that the use of the *Pobon Pintar* game media significantly enhances early numeracy skills among children aged 5–6 years compared to traditional number card instruction. By engaging learners in playful, hands-on interaction, the *Pobon Pintar* fosters both cognitive understanding and motivation in counting activities. This research contributes to early childhood education by providing empirical evidence for the effectiveness of locally developed, low-cost learning tools that integrate play and mathematics. Its implications extend to curriculum design and teacher training, emphasizing the role of creative and interactive media in foundational numeracy development. Future research should employ randomized controlled designs, explore long-term retention, and test the scalability of similar educational play media in diverse learning contexts.

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South Sulawesi-Indonesia

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